# CONSOLIDATED REPORT OF CGMS ACTIVITIES

**10 Edition, Version 10**

**13 November 2003**

# CGMS CONSOLIDATED REPORT

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# CGMS CONSOLIDATED REPORT

## 1. INTRODUCTION

The Coordination Group for Meteorological Satellites (CGMS) provides a forum for the exchange of technical information on geostationary and polar-orbiting meteorological satellite systems, such as reporting on current meteorological satellite status and future plans, telecommunication matters, operations, inter-calibration of sensors, processing algorithms, products and their validation, data transmission formats and future data transmission standards.

A global network of satellites evolved during the 1960's and 1970's following the successful demonstration of the large benefits shown by the USA's TIROS Operational System (TOS) and Applications Technology Satellites (ATS-1 and ATS-3) for meteorological applications.

There are two major components in the current meteorological satellite network. One element consists of the various geostationary meteorological satellites operated by Europe, China, India, Japan, the United States of America and the Russian Federation. These satellites operate on the equatorial belt and provide a continuous view of the weather from approximately 70 degrees North to 70 degrees South. The launch of the first GOES satellite in 1974 by the USA was followed in 1977 with the launches of GMS by Japan and METEOSAT by the European Space Agency (responsibility for this satellite now rests with the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT). The network was augmented in 1983 with the launch of the INSAT-1A, in 1994 with the launch of the Russian Federation's GOMS-N1 and in 1997 with the launch of FY-2A by China.

The second major element comprises the polar-orbiting satellites operated by the Russian Federation, China and the United States of America. A diagram of the nominal two component space-based system of the Global Observing System (GOS) can be seen below.

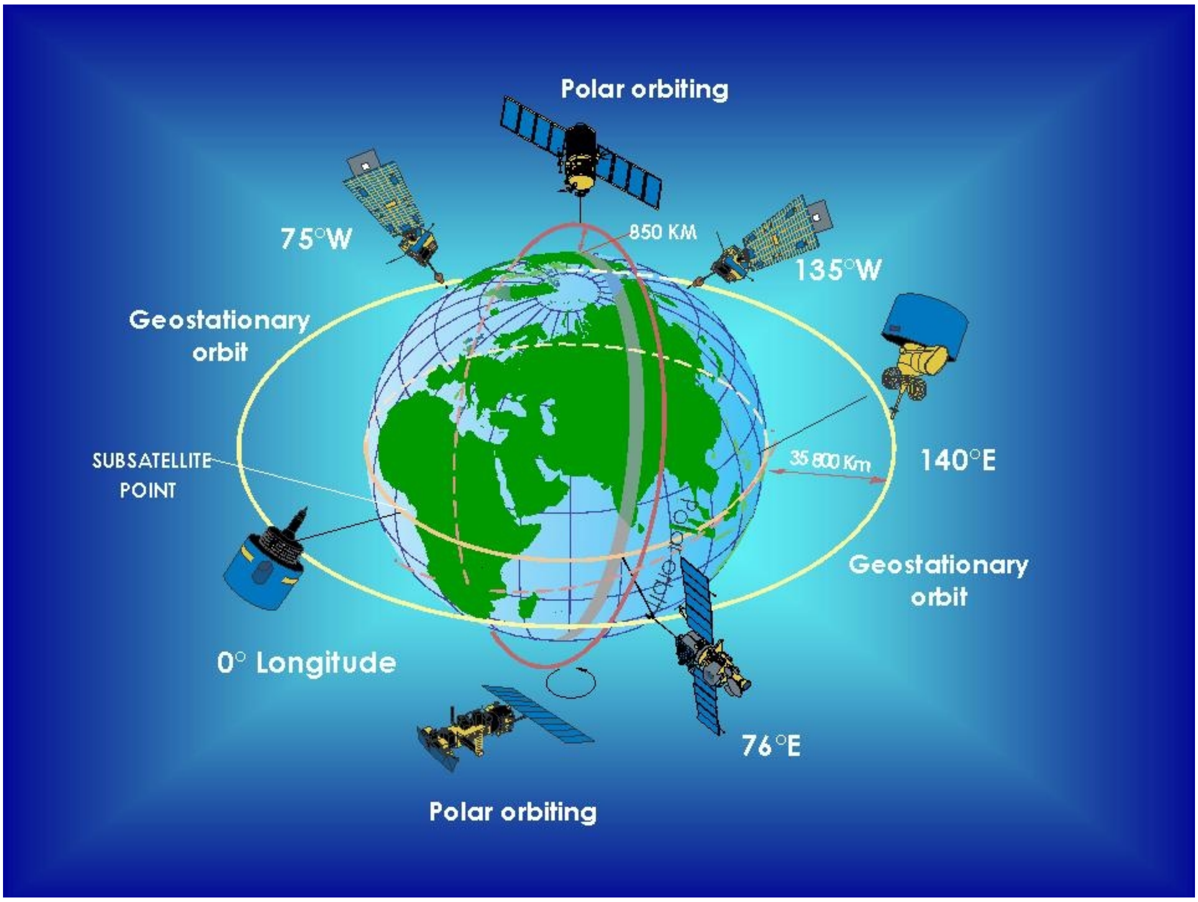
Since 1972, the Coordination Group for Meteorological Satellites (CGMS) has provided a forum, in which the satellite operators have studied, jointly with the WMO, technical operational aspects of the global network, so as to ensure maximum efficiency and usefulness through proper coordination in the design of the satellites and in the procedures for data acquisition and dissemination. The specific design of each of the satellites is based on national and regional requirements for data and services and therefore some differences in design and mission are inevitable. However, the regular meetings of the group have permitted a gathering and exchange of results during the course of the development of each system and a considerable measure of coordination has been achieved.

**About this publication**

This Consolidated Report provides general information on CGMS membership and activities:

- as a source of information for all individuals who are interested in meteorological satellite systems world-wide, and
- as a reference for CGMS Members.

The information focuses on common CGMS achievements and agreed CGMS provisions.




## 1.1. HISTORY AND OBJECTIVES

CGMS came into being on 19 September 1972, when representatives of the European Space Research Organisation (since 1975 called the European Space Agency), Japan, the United States of America and observers from the World Meteorological Organization (WMO) and the Joint Planning Staff for the Global Atmospheric Research Programme met in Washington to discuss questions of compatibility among geostationary meteorological satellites. The meeting identified several areas, in particular for the collection of data from moving platforms and for WEFAX image dissemination, where both technical and operational coordination would be needed.

It was decided at the original CGMS meeting in Washington to establish two working groups, one under the designation "System Engineering Working Group" to study the engineering aspects, and the other entitled "User Considerations Working Group" to look after the interests of future users.

CGMS I, furthermore, concluded that a meeting of Senior Officials of the participating agencies should be held each time immediately following the meetings of the technical working groups to finalise the report of the meeting and to approve decisions, recommendations and actions. It was recognised from the beginning, however, that these senior officials could commit only their own organisations and not Governments of the sponsoring states. Hence, some decisions had to be approved *ad referendum* even by the meeting of Senior Officials. In practice, this has aided the freedom of discussion and enabled the Senior Officials – through the prestige gained over the years by CGMS – to succeed in some rather impressive and far-reaching accomplishments.

It was at CGMS II, held in Zurich, Switzerland, in January 1973, that the group adopted the name "Coordination of Geostationary Meteorological Satellites" and the abbreviation "CGMS". In the course of CGMS activities, it appeared that some items were related simultaneously to both of the above-mentioned working groups. In the beginning of CGMS such items were resolved by exchanging temporarily individual experts between the two working groups. CGMS V however, introduced the idea of "joint sessions". In subsequent meetings this resulted in the establishment of an autonomous "Joint Working Group", acting on its own agenda and generating, by CGMS VII, a separate report to the Senior Officials.

The then Union of Soviet Socialist Republics (USSR), having expressed its intention to develop and operate a geostationary meteorological satellite, GOMS, joined the small group of satellite operators in January 1973. At that time WMO became a full member of CGMS and the then USSR cooperated in developing the technical elements and operational principles for the system of geostationary satellites.

Since 1983, India has operated a series of geostationary telecommunications satellites (INSAT) with an imaging radiometer on board and, since September 2002, a dedicated geostationary meteorological satellite (METSAT). India joined CGMS in 1979.

EUMETSAT joined CGMS in 1987 and currently provides the CGMS Secretariat. Since 1995 EUMETSAT became the operator of the Meteosat satellite series replacing ESA which, remains the development agency for Meteosat Second Generation (MSG) and the future Metop polar orbiting meteorological satellites.

The People's Republic of China (PRC), having developed both polar-orbiting and geostationary meteorological satellites (FY1 and FY2 series, respectively) joined CGMS in 1989.

In recognition of the importance of having representation from the ocean community within CGMS, UNESCO/IOC joined CGMS in 2001.

CGMS Members formally adopted the final draft of a new Charter on 31 January 1992. The new charter extended the area of responsibilities for CGMS to include both geostationary and polar-orbiting meteorological satellites. Incidentally, it also changed the name of the group, whilst maintaining the well-recognised abbreviation CGMS. CGMS meetings have been held as follows (highlighted link indicates report available online):

| | | |
|---|---|---|
| CGMS I | 19-20 September 1972 | Washington |
| CGMS II | 18-24 January 1973 | Zurich |
| CGMS III | 11-18 October 1973 | Tokyo |
| CGMS IV | 13-17 May 1974 | Geneva |
| CGMS V | 18-25 April 1975 | Geneva |
| CGMS VI | 5-9 April 1976 | Washington |
| CGMS VII | 24-31 January 1977 | Geneva |
| CGMS VIII | 13-17 March 1978 | Paris |
| CGMS IX | 5-9 March 1979 | Tokyo |
| CGMS X | 7-21 March 1980 | Geneva |
| CGMS XI | 8-12 February 1982 | Washington |
| CGMS XII | 25-28 April 1983 | Paris |
| CGMS XIII | 10-13 April 1984 | Geneva |
| CGMS XIV | 20-24 May 1985 | Tokyo |
| CGMS XV | 3-7 November 1986 | New Delhi |
| CGMS XVI | 28 September - 2 October 1987 | Washington |
| CGMS XVII | 3-7 October 1988 | Darmstadt |
| CGMS XVIII | 13-17 November 1989 | Geneva |
| CGMS XIX | 10-14 December 1990 | Tashkent |
| CGMS XX | 27-31 January 1992 | Tokyo |
| CGMS XXI | 19-23 April 1993 | Beijing |
| CGMS XXII | 11-15 April 1994 | Annapolis |
| CGMS XXIII | 15-19 May 1995 | Darmstadt |
| CGMS XXIV | 22-26 April 1996 | Lauenen |
| CGMS XXV | 2-6 June 1997 | St. Petersburg |
| CGMS XXVI | 6-10 July 1998 | Nikko, Japan |
| CGMS XXVII | 13-18 October 1999 | Beijing |
| CGMS XXVIII | 16-20 October 2000 | Woods Hole |
| CGMS XXIX | 22-25 October 2001 | Capri |
| CGMS XXX | 11-14 November 2002 | Bangalore |
| CGMS XXXI | 10-13 November 2003 | Ascona |

## 1.2. MEMBERSHIP OF CGMS

The table of members shows the lead agency in each case. Delegates are often supported by other agencies, for example, ESA (with EUMETSAT), NASDA (with Japan), NASA (with NOAA) and ISRO (with IMD). The current Membership of CGMS is (in alphabetical order):

| | | |
|---|---|---|
| China Meteorological Administration | - | joined 1989 |
| EUMETSAT | - | joined 1987, CGMS Secretariat |
| India Meteorological Department | - | joined 1979 |
| IOC/UNESCO | - | joined 2001 |
| Japan Meteorological Agency | - | founder member, 1972 |
| NOAA/NESDIS | - | founder member, 1972 |
| ROSHYDROMET* | - | joined 1973 |
| WMO | - | joined 1973 |
| ESA | - | re-joined 2003 |
| NASA | - | joined 2003 |
| JAXA | - | joined 2003 |
| Rosaviacosmos | - | joined 2003 |

At CGMS XXX, in 2002, Members agreed to invite, as full members of CGMS, ESA, NASA, NASDA and Rosaviacosmos, all being operators of R & D satellites, and with the understanding that these Agencies would contribute to the space based component of the Global Observing System (GOS) by providing access to their R & D satellite mission data.

## 1.3. ROLE OF WMO

The World Meteorological Organization, a specialised agency of the United Nations, has a membership of 185 states and territories (as of June 2000). Amongst the many programmes and activities of the organization, there are three areas which are particularly pertinent to the activities of CGMS:

- To facilitate world-wide cooperation in the establishment of networks for making meteorological, as well as hydrological and other geophysical observations and centres to provide meteorological services,
- To promote the establishment and maintenance of systems for the rapid exchange of meteorological and related information,

* ROSHYDROMET is the Russian Federal Service for Hydrometeorology and Environmental Monitoring

- To promote the standardisation of meteorological observations and ensure the uniform publication of observations and statistics.

The main purpose of the WMO Satellite Activities Programme is:

- To coordinate environmental satellite matters and activities throughout all the WMO Programmes and to give guidance to WMO and other multi-sponsored programmes on the potential of remote-sensing techniques in meteorology, hydrology, related disciplines and their applications.

Satellites have become a fundamental tool for the WMO to carry out its basic goals. The WMO needs to play a role in the coordination of the global network of meteorological satellites because of the data and services provided to the large number of countries who are neither satellite operators nor members of a consortium operating such satellites. This is also very pertinent for the large parts of the globe outside national jurisdiction, especially the large open ocean areas.

The WMO, in its endeavours to promote the development of a global meteorological observing system, participated in the activities of CGMS from its first meeting. There are several areas where joint consultations between the satellite operators and WMO are needed. The provision of data to meteorological centres in different parts of the globe is achieved by means of the Global Telecommunication System (GTS) in near-real time. This automatically involves assistance by WMO in developing appropriate code forms and provision of a certain amount of administrative communications between the satellite operators.

The active involvement of WMO has allowed the development and implementation of the operational ASDAR system as a continuing part of the Global Observing System (GOS). Furthermore, the implementation of the IDCS system was promoted by WMO and acted jointly with the satellite operators as the admitting authority in the registration procedure for IDCPs.

The long-term objectives of the WMO Satellite Activities programme are:

(i) To participate in the development of the Global Observing System (GOS) as a composite system, particularly for upper-air observing based on an optimal mix of observing components, including ground-based remote-sensing, mobile observing platforms, satellite and Global Position System-Meteorology (GPS-MET). GOS support to meeting GCOS requirements for climate monitoring and prediction is also a priority goal;

(ii) To assist Members in the transition of the low-resolution imagery satellite services from analogue to digital under complex operational conditions;

(iii) To promote satellite-related high quality continuing education to keep the knowledge and skill of Members operational and scientific staff up-to-date with the latest technological innovations, and to provide the competence and skills needed in related fields, such as communication with users;

(iv) To provide information, advice and guidance to Members on satellite-related technological developments as well as on changes in relevant existing meteorological and hydrological operation systems to enable them to develop plans for objective and wise investment actions.

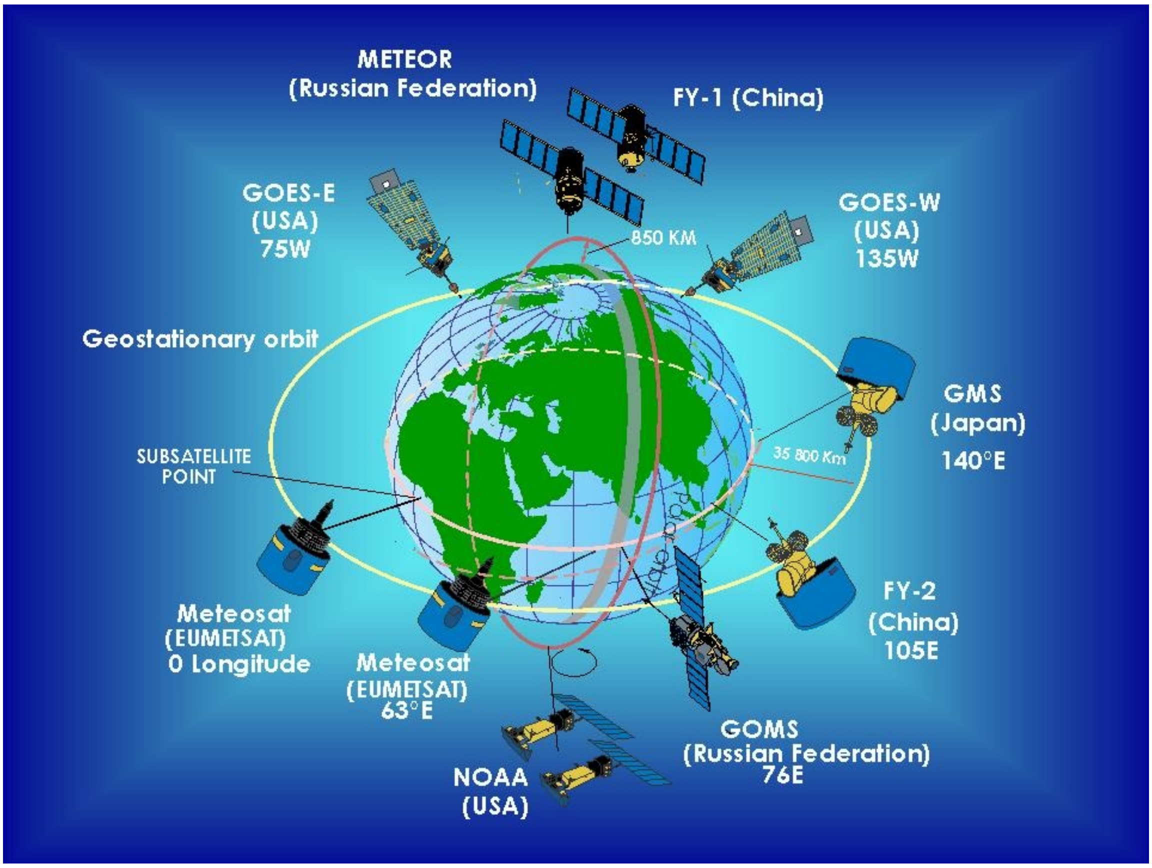
The WMO is incorporating the information on geostationary and polar-orbiting satellite data and major products into the revision of the WMO Publication No. 411, "Information on Meteorological and other Environmental Satellites", which provides information on satellite programmes operated by Members and Organisations. Revisions have been issued in 1989, 1994 and 2001.

## 1.4. THE GLOBAL ROLE OF SATELLITES

The global network of meteorological satellites, whose technical and operational coordination is the objective of CGMS, constitutes a major portion of the space-based component in the Global Observing System (GOS) of the World Weather Watch (WWW). This network design evolved during the period from 1965 to 1978 as a portion of the Global Atmosphere Research Programme (GARP). The GARP and WWW are responses of the WMO and International Council of Scientific Unions (ICSU) to three resolutions of the General Assembly of the United Nations, calling for international programmes in Meteorology for the benefit of mankind. WWW is a continuing programme of WMO to assist meteorological services in all parts of the world in operational and research functions by making available basic meteorological and other relevant data. The GOS provides the input data for numerical weather prediction models. GARP was a research effort, sponsored jointly by WMO and ICSU, to gain a better understanding of the laws and the behaviour of the Earth's atmosphere. This is important both for improving operational forecasting and for a better determination of the influence of human activities on the atmosphere. The World Climate Programme is a follow-on to the GARP activities.

CGMS members contributed to the implementation of the first GARP Global Experiment (FGGE) by developing the network of 5 geostationary satellites shown in the figure above. FGGE was started in September 1978 with a build-up phase, followed by a 12 months operational phase starting 1 December 1978. The latter included two special observing periods of one month's duration (15 January to 15 February 1979 for the first and 15 May to 15 June 1979 for the second), where all components of the GARP Global Observing System were simultaneously in operation.

Since approximately 70 per cent of the Earth's surface is water and even the land areas have many regions which are sparsely inhabited, the polar-orbiting satellite system provides the data needed to fill-in the gaps of surface and atmospheric temperature profiles over the areas not adequately covered by conventional observing systems particularly in the Southern Hemisphere and in high latitudes both in the Arctic and Antarctic. Circling the Earth in a near-polar orbit, these spacecraft are able to acquire data from all parts of the globe in the course of a series of successive revolutions. With a relatively low altitude their sensors can acquire higher-resolution data, both spatially and spectrally, than can the high-altitude geostationary satellites. For these reasons the polar-orbiting satellites are principally used to obtain specific sets of observations of three main types: a) daily global cloud cover; b) reasonably accurate quantitative measurements of surface temperature and c) most important, the vertical variation of temperature and water vapour in the atmosphere. The following diagram shows the current configuration of the space-based sub-system of the Global Observing System:



The importance of operational continuity and reliability for the global coverage from satellites was discussed at the CGMS XIII and XIV sessions. In particular, all satellite operators were asked at CGMS XIV to re-examine the opportunities and constraints for redeployment of satellites in the event of failures of one or more geostationary meteorological satellites in the network. WMO at CGMS XV presented a comparison of several different strategies for achieving reliability and coverage on a global scale. This comparison strongly indicated that a strategy based on the redeployment of operating satellites has limited utility due to the inability to rationalise the needs for geographical coverage by different users and due to the presence of different types of spacecraft.

EUMETSAT, also at CGMS XV, proposed that a strategy based on deployment of spare satellites, with satellite control maintained by the satellite owner, could be useful in alleviating the affects due to satellite failures in the neighbouring positions of the spare satellite owner. It was agreed that this proposal had merit, especially for the near-term and should be developed further as a potential basis for system to be developed and operated during the rest of the century.

CGMS XV also considered the strategy of overlapping satellite coverage with a resultant "fail-soft" global network that was one of the alternative strategies analysed by WMO. CGMS members endorsed the idea of increased direct participation in geostationary meteorological satellite operations and agreed that countries such as the People's Republic of China, who were at the time actively considering the operation of a geostationary meteorological satellite, should be strongly encouraged. It was recognised that such additional satellites would provide some overlapping coverage and thus provide the basis for a "fail-soft" system over several regions.

At CGMS XVI, the Group recognised that the discussion of common back-up satellites had been too general and represented a goal that might seem too difficult and too distant. It was decided that at future meetings this matter would be discussed under more precise and limited agenda headings. The concept of regional "help your neighbour" schemes, proposed by EUMETSAT at CGMS XV seemed a more realistic approach to the problem.

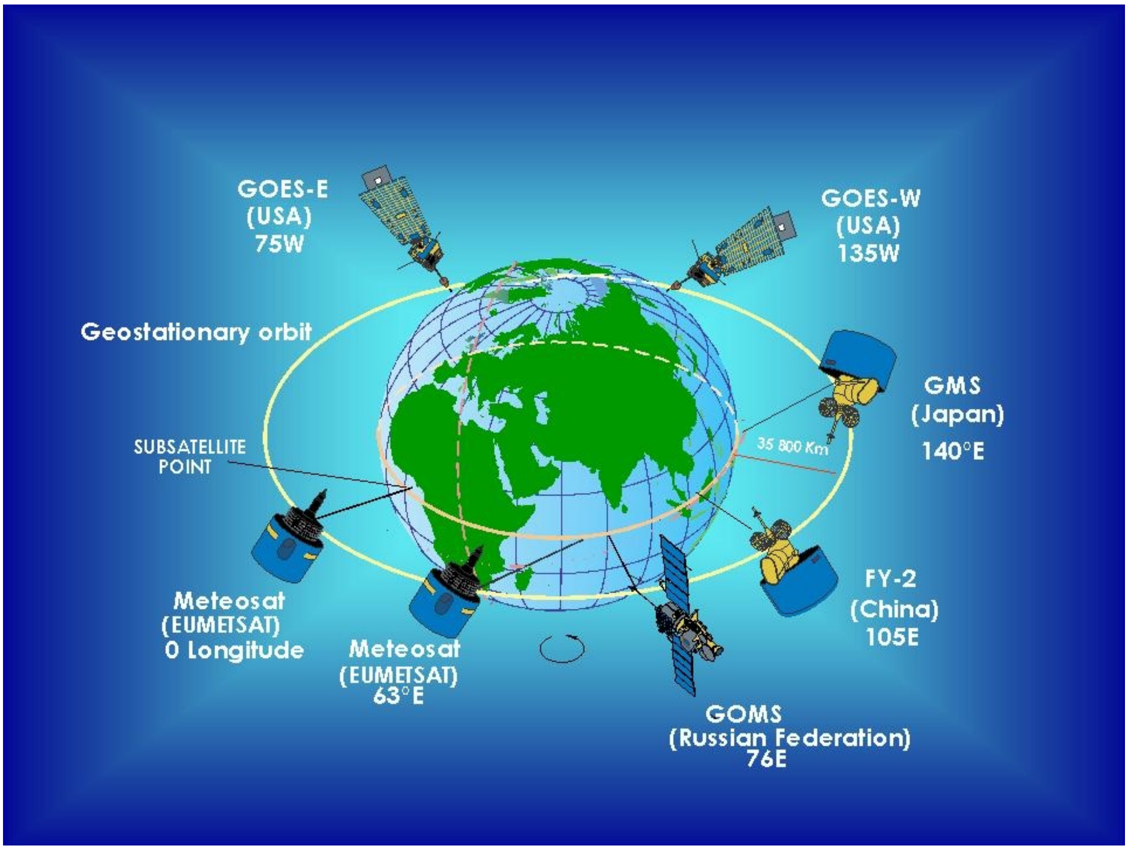
## 2. COORDINATION OF SATELLITE SYSTEMS

### 2.1. GEOSTATIONARY SATELLITE SYSTEMS AND THEIR MISSIONS

The nine geostationary meteorological satellite systems currently in operation are provided by:

| | |
|---|---|
| EUMETSAT | (two Meteosat spacecraft) |
| Russian Federation | (one GOMS spacecraft) |
| Japan | (one GMS spacecraft) |
| USA | (two GOES spacecraft) |
| India | (one INSAT and one METSAT spacecraft) |
| China | (one FY-2 spacecraft) |

These satellites are more or less evenly positioned around the Earth in geostationary orbit and their positions are as shown below.




All these satellite systems have been designed to fulfil the following mission objectives:

- High-resolution imaging of the Earth's surface and of its cloud coverage, in the visible and thermal infrared spectra, and extraction of meteorological information such as cloud motion wind vectors, sea surface temperatures, cloudiness and cloud top heights from the image data.

- Dissemination of cloud cover images and other meteorological information to User Stations.

- Collection and relay of environmental data from fixed or mobile Data Collection Platforms, located either on the Earth's surface or in the atmosphere.

The design characteristics of all the geostationary meteorological satellite systems differ from one to another, but they bear a general similarity in their mission performance:

- They all carry scan imagers to provide high-resolution full disc images in the visible and in the infrared. The useful coverage of these images, in particular for acceptable wind vector extraction, extends up to 50 or 55 degrees around the sub-satellite points. They employ comparable imaging techniques; i.e. a maximum of 48 full earth images per day can be generated by each satellite system.

- They all include data relay capabilities for the dissemination of images and data collection. Furthermore, since these two missions affect a wide community of users operating APT stations, Data User Stations and Data Collection Platforms, the transmission characteristics and the operational procedures have been standardised. The coverage of the data relay capability extends up to about 75 degrees around each sub-satellite point.

A global overview of current geostationary meteorological satellites is presented in the following table (valid 22 December 2002).

**Table 2.1.: Current Geostationary Satellites Coordinated within CGMS**
*(as of 13 November 2003)*

| SECTOR | **Satellites currently in orbit (+type)**<br>P: Pre-operational<br>Op: Operational<br>B: Back-up<br>L: Limited availability | **Operator** | **Loca-Tion** | **Launch date** | **Status** |
|---|---|---|---|---|---|
| EAST-PACIFIC **(180°W-108°W)** | GOES-10 (Op) | USA/NOAA | 135°W | 04/97 | Inverted, solar array anomaly, DCP interrogator on back-up |
| | GOES-8 (L) | USA/NOAA | 147.6° W | 4/94 | Drifting West at 1.06° per day, Back-Up to GOES-9 |
| WEST-ATLANTIC **(108°W-36°W)** ***(continued)*** | GOES-11 (B) | USA/NOAA | 105°W | 05/00 | In-orbit back-up, 48 hours availability |
| **SECTOR** | **Satellites currently in orbit (+type)**<br>P: Pre-operational<br>Op: Operational<br>B: Back-up<br>L: Limited availability | **Operator** | **Loca-Tion** | **Launch date** | **Status** |
| ***(continued)*** WEST-ATLANTIC **(108°W-36°W)** | GOES-12 (Op) | USA/NOAA | 75°W | 7/ 01 | Fully Functional |
| | METEOSAT-7 (Op) | EUMETSAT | 0° | 02/97 | Functional |
| EAST ATLANTIC **(36°W-36°E)** | METEOSAT-6 (B) | EUMETSAT | 9.5° | 11/93 | Rapid Scanning Service minor gain anomaly on IR imager |
| | MSG-1 (P) (METEOSAT-8 when Op) | EUMETSAT | 10.5°W | 28/08/02 | Commissioning phase. |
| INDIAN OCEAN **(36°E-108°E)** | METEOSAT-5 (Op) | EUMETSAT | 63°E | 03/91 | IODC, functional but high inclination mode |
| | GOMS-N1 (B) | RUSSIA | 76°E | 11/94 | Since 9/98 in stand-by |
| | FY-2B (Op) | CHINA | 105°E | 06/2000 | Image transmission interrupted in eclipse periods |
| | FY-2A (B, L) | CHINA | 86.5°E | 06/97 | |

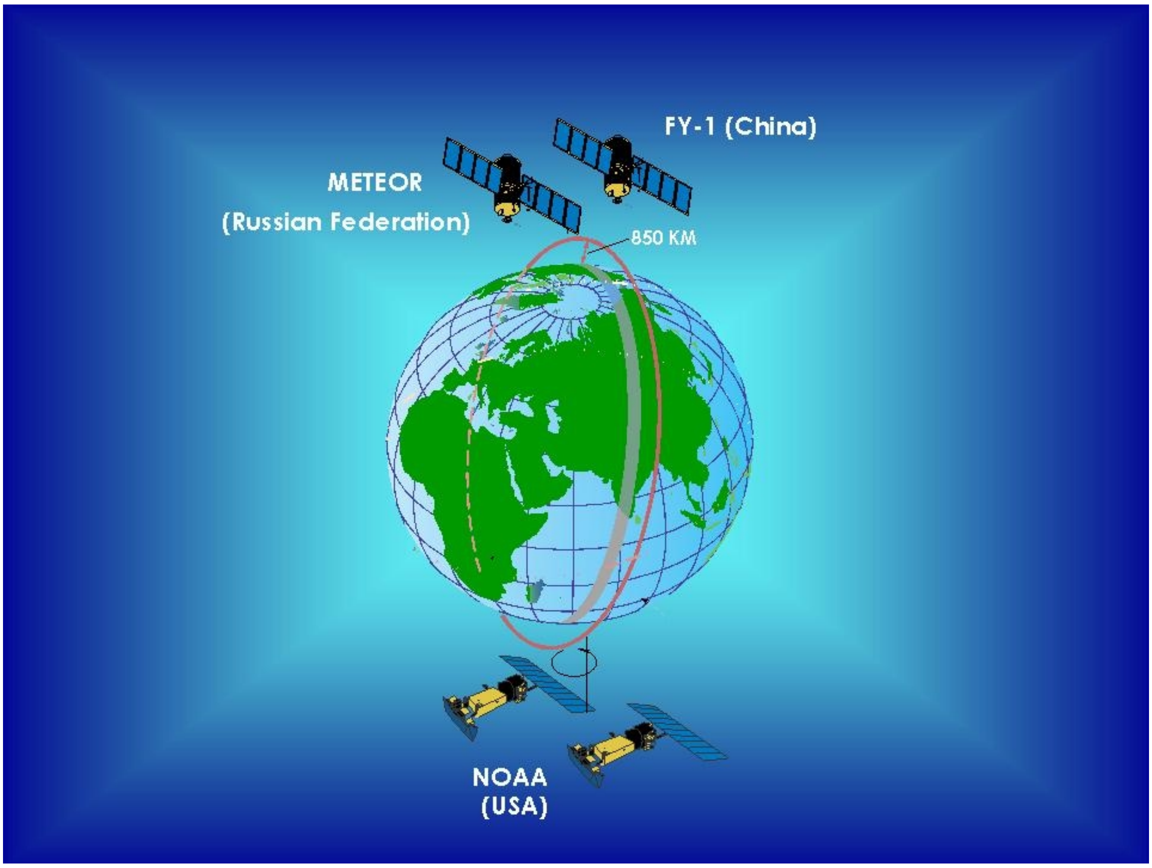
| | | | | | |
|---|---|---|---|---|---|
| | INSAT II-B (B) | INDIA | 111.5°E | 07/93 | Back-up satellite from an inclined orbit inclined orbit mode of operation. IR channel not available. |
| | INSAT II-C | INDIA | 48.0°E | | |
| | INSAT II-E (Op) | INDIA | 83°E | 04/99 | Imagery data from three channel CCD payload (1km res.) available for operational use. 3 channel VHRR not available for use. |
| | INSAT III-C | INDIA | 74°E | 24/01/02 | No met payload used for dissemination of processed met data in broadcast mode. No WEFAX broadcast capability. |
| | INSAT-III-A | INDIA | 93.5°E | 10/04/03 | Operationalisation date:24/04/03. A 3-channel VHRR imager and CCD payload available for use similar to II-E. |
| | KALPANA-1 (Op) | INDIA | 74°E | 12/09/02 | Dedicated meteorological satellite. |
| **WEST-PACIFIC (108°E- 180°E)** | GOES-9 (L) | USA/NOAA | 155°W | 05/95 | At 155° E, now providing Data to Japan. |
| | GMS-5 (Op) | JAPAN | 140° E | 03/ 95 | The backup of GMS-5 with GOES-9 was started on 22 May 2003. |

## 2.2. POLAR-ORBITING SATELLITE SYSTEMS AND THEIR MISSIONS

The seven polar-orbiting meteorological satellite systems are currently operational and provided by:

| | |
|---|---|
| Russian Federation | (two METEOR spacecraft) |
| USA | (two NOAA and two DMSP spacecraft) |
| China | (one FY-1 spacecraft) |

These satellites circle the Earth each 100 minutes passing nearly over the North and South Poles. Each satellite sees the entire planet twice per 24 hours. The following diagram shows the current polar-orbiting satellites systems.




A global overview of current polar orbiting meteorological satellites is presented in the following table (valid 22 December 2002).

## Table 2.2.: Current Polar-Orbiting Satellites Coordinated Within CGMS

*(as of 13November 2003)*

| **Orbit type (equatorial crossing times)** | **Satellites in orbit** (+operation mode) P=Pre-operational Op=operational B=back-up L=limited availability | **Operator** | **Crossing Time** A=Northw D=Southw +Altitude | **Launch date** | **Status** |
|---|---|---|---|---|---|
| **Sun-synchr. "Morning" (6:00 – 12:00) (18:00 – 24:00)** | NOAA-17 (Op) | USA/NOAA | 10:02 (D) 812 km | 6/02 | Functional. |
| | NOAA-15 (B) | USA/NOAA | 07:04 (D) 810 km | 05/98 | Functional (problems with AVHRR +HIRS) |
| | NOAA-12 (L) | USA/NOAA | 04:47 (D) 808 km | 05/91 | Functional (except sounding). |
| | DMSP-F15 (Op) | USA/NOAA | 21:31 (A) 850 km | 12/99 | Defense satellite. Data available to civilian users through NOAA. |
| | DMSP-F14 (B) | USA/NOAA | 20:14 ( A ) 852 km | 04/97 | Defense satellite. Data available to civilian users through NOAA. |
| | DMSP-F12 (L) | USA/NOAA | 18:56 (A) 850 km | 8/94 | Defense Satellite. Non-operational (no onboard recorders). |
| | RESURS-01-N4 (P) | Russia | 09:30 (A) 835 km | 7/98 | Temporarily out of operations |
| | METEOR-3M-N1 (P) | Russia | 9:15 | 10Dec01 | Functional. In commissioning phase till end of 2002. |
| | ERS-1 (R) | ESA | 10:30 (D) 785 km | 07/91 | Replaced by ERS-2 in 03/00 after an overlapping period |
| | ERS-2 (R) | ESA | 10:30 (D) 785 km | 04/95 | Due to OB recorder problems in 06/03, the LBR mission is ensured over ESA acquisition stations only. |
| | Envisat (R) | ESA | 10:000 (D) 800 km | 03/02 | |
| | PROBA (R) | ESA | 10: 30 ( D) 615 km | 10/01 | Drifting orbit. Technology experiment. AO Science mission: 2003. |
| **Sun-synchr. "Afternoon" (12:00 –16:00) (00:00 – 04:00)** | NOAA-16 (Op) | USA/NOAA | 13:53 (A) 851 km | 09/00 | Functional, no APT. |
| | NOAA-14 (B) | USA/NOAA | 18:07 (A) 847 km | 12/94 | Functional. 0ne OBP is unusable. |
| | NOAA-11 (B) | USA/NOAA | 22:42 (A) 843 km | 09/88 | Functional. SBUV data limited. |
| **Sun-synchr. "Early morning" ( 4:00 - 6:00) (16:00 – 18:00)** | DMSP-F13 (Op) | USA/NOAA | 18:18 (A) 850 km | 03/95 | Defense satellite. Data available to civilian users through NOAA. |
| **Sun-synchr. "morning"** | FY-1C (B) | China | 7:36 (D) 866 km | 5/99 | Functional. CHRPT |
| | FY-1D (Op) | China | 08:40 873 km | 15May02 | Functional. CHRPT |

## 2.3 SATELLITE SYSTEM CONTINGENCY PLANS

The operational continuity and reliability of global coverage is an important requirement of the space-based global observing system. There have, consequently, been regular discussions on contingency planning by the satellite operators at CGMS meetings. Distinction has been made between:

- regional contingency plans: what is planned by the satellite operator to maintain operational continuity,
- inter-regional contingency plans: what is foreseen by neighbouring satellite operators to remedy a failure of one of their satellites,
- global contingency plans: what is agreed by all satellite operators to remedy the failure of any one of the existing operational satellites.

### 2.2.1. Inter-regional contingency arrangements

So far, there have been two examples of inter-regional contingency arrangements between the USA and Europe. From 1985 to 1988, NOAA repositioned its GOES-4 spacecraft to fill a gap over Europe created by the loss in DCS service from Meteosat-2. In the beginning of 1991 EUMETSAT repositioned its Meteosat-3 to back-up the ageing GOES-7 in providing Atlantic Ocean image coverage. This latter arrangement was referred to as the Atlantic Data Coverage (ADC), which eventually became Extended Atlantic Data Coverage (XADC), from January 1993 to May 1995, when ESA/EUMETSAT moved Meteosat-3 westward from 50° West to 75° West, using upgraded facilities at the NOAA Wallops Island ground station.

Following the success of these contingency operations, NOAA and EUMETSAT have since concluded a long-term agreement on back-up of operational geostationary meteorological satellite systems.

Another example of inter-regional contingency satellite operations occurred in the Pacific region in the autumn of 1992, using temporary DCS support capacity provided by the Japanese GMS-4 for data collection of regional DCP which would normally use the GOES DCS International Channel I16.

### 2.2.2. Global Contingency Plans

In 1991, the forty-fourth Executive Council of WMO recommended the development of contingency plans by the satellite operators to increase the reliability of the space-based global observation system. WMO considered that space segment contingency planning was the core of the statement of WMO requirements for system continuity. It was anticipated that CGMS would continue its role of coordination and standardisation such that ground receiving equipment would be able to receive and process services from any contingency satellite provided by another operator, e.g. by using standardised down-link broadcasts and data formats. In 1992, the statement of WMO requirements for continuity was endorsed by the satellite operators, who subsequently established a CGMS Working Group on Global Contingency Planning.

At the first meeting of this Working Group in October 1992, CGMS concluded that no single satellite operator could be expected to guarantee satellite availability in all circumstances and that the establishment of joint contingency plans was essential in order to achieve a reliable global system at a realistic cost. A proposal for a contingency concept, which could meet global needs, was thus established. This concept was based upon a philosophy of assisting neighbouring satellite operators by using data transfer techniques similar to that already developed for the Europe-USA Extended Atlantic Data Coverage scheme mentioned above.

In 1994, the CGMS Working Group on Global Contingency Planning agreed a technical strategy based upon the “help your neighbour” concept. This strategy assumes that each satellite operator tries, with its best efforts, to maintain its nominal configuration, in accordance with its own constraints. Any CGMS satellite operator faced with a contingency situation, whereby priority satellite based services cannot be supported, should immediately discuss the situation with other satellite operators who, in good faith, should try to find a solution.

In 1997, CGMS considered that it would be beneficial for the user community to develop similar arrangements to cover unexpected contingencies affecting services provided by the satellite operators.

In 1998, Japan and China looked into possible contingency arrangements to support each other’s services. The GMS and FY-2 satellite systems have a high level of compatibility with regard to area of the globe covered and transmission characteristics. However, it was decided that long-term contingency arrangements could only be considered if respective launch schedules allowed sufficient in-orbit redundancy. A constraint to the provision of a back-up of MTSAT or FY-2 was the incomplete overlap (70%) in the fields of view of GMS/MTSAT and FY-2.

Bearing this in mind, the Working Group on Global Contingency Planning considered that in the event of a major system failure, back-up in areas such as product generation might be an appropriate solution. As a consequence, the satellite operators are currently actively studying such possibilities for support to product generation using data from neighbouring satellite systems.

Additionally, in 1998, discussions were initiated between EUMETSAT and the Russian Federation with a view to investigating possibilities for the use of Meteosat-5 at 63°E to relay Russian Federation DCP messages and provide a temporary WEFAX image dissemination service in the region.

Also in 1998, India agreed to transmit to its higher authorities the need for regional contingency planning as stipulated in the CGMS Contingency Strategy. To this end, EUMETSAT has concluded an Agreement with ISRO for the possible relay of some INSAT imagery and products via the Meteosat system. In return, India will have access to imagery provided by Meteosat-5 located at 63°E.

In 2001 the Working Group on Global Contingency was pleased to note that several satellite operators had initiated discussions of regional contingency plans with neighbours. However it was generally agreed that such contingency plans could only be activated on the assumption that there was a nominal satellite configuration operated by the service provider. Also in 2001, concerning the polar orbiting meteorological satellites, the Working Group recommended that a global plan be developed with respect to the morning and afternoon orbits. In preparation for further discussion of the above topics at CGMS XXX, it was agreed that a special meeting of the Working Group would be hosted by WMO in February 2002, at the time of the WMO Executive Council Consultative Meeting on High Level Policy on Satellite Matters.

At the February 2002 meeting of the CGMS Global Contingency Planning Working Group, there was recognition that short-term bilateral contingency agreements logically preceded both long-term bilateral agreements and global agreements. Long-term bilateral agreement would take effect once both parties had established their planned baseline configuration. These baseline configurations, planned to be in place sometime in the first decade of the twenty-first century, will provide for robust national programmes and will also have some capability to back up other agencies' programmes in an emergency situation.

Also since the 2001 meeting of the Group, EUMETSAT had agreed to maintain a satellite at 63° East Longitude so long as such service should be required to meet minimum WMO requirements. This satellite was now referred to as "Meteosat Indian Ocean Data Coverage (IODC)."

The Working Group felt that a major milestone had been achieved in the discussions on geostationary contingency planning. First, most CGMS satellite operators either had in place, were developing or would consider when nearing nominal configuration, regional contingency plans. Secondly, the satellite operators would follow the principles of "help your neighbour" and be willing to be "helped by your neighbour". Thirdly, nominal configurations for most satellite operators now included either an "in-orbit spare" or an "on-demand launch". The Working Group agreed that the set of regional contingency plans would constitute a *de facto* global contingency plan in response to the WMO requirements.

A global overview of future geostationary meteorological satellites is presented in table 2.3.1 followed by an overview of future polar-orbiting meteorological satellites in table 2.3.2.

## Table 2.3.1: Future Geostationary Satellites Coordinated within CGMS

*(as of 13 November 2003)*

| Sector | Future additional satellites | Operator | Planned launch | (Planned location) Other remarks |
|---|---|---|---|---|
| **EAST PACIFIC (180°W-108°W) AND WEST ATLANTIC (108°W-36°W)** | GOES-N | USA/NOAA | 12/2004 | 135°W or 75°W |
| | GOES-O | USA/NOAA | 2007 | 135 W or 75°W |
| | GOES-P | USA/NOAA | 2008 | 135°W or 75°W |
| | GOES-R | USA/NOAA | 2012 | 135°W or 75°W |
| | MSG-2 | EUMETSAT | 01/2005 | 0° |
| | MSG-3 | EUMETSAT | 01/2009 | 0° |
| | MSG-4 | EUMETSAT | 2010/2011 | 0° |
| **INDIAN OCEAN (36°E-108°E)** | GOMS-N2 | Russia | 2006 | 76° E |
| | INSAT-3D | India | 2006 | Location TBD. Dedicated meteorological mission. Improved 6 channel imager and a 19 channel sounder. |
| | FY-2C | China | 2004 | Improved FY-2 series, 5 channel VISSR, LRIT |
| | FY-2D | China | 2006 | Improved FY-2 series, 5 channel VISSR, LRIT |
| | FY-2E | China | 2009 | Improved FY-2 series, 5 channel VISSR, LRIT |
| **WEST PACIFIC (108°E- 180°E)** | MTSAT-1R | Japan | 02/2004 | Multifunctional Transport Satellite 140°E |
| | MTSAT-2 | Japan | 2005 (FY) | Multifunctional Transport Satellite 140°E. It will be acting as back-up to MTSAT-1R until 2009. MTSAT-1R will be used as back-up. |

**Table 2.3.2: Future Polar-Orbiting Satellites Coordinated within CGMS**
*(as of 13 November 2003)*

| **Orbit type (equatorial crossing times)** | **Future additional Satellites R = R & D** | **Operator** | **Planned launch date** | **Other information** |
|---|---|---|---|---|
| **Sun-synchr. "Morning" (6:00 – 12:00) (18:00 – 24:00)** | METOP-1 | EUMETSAT | 09/2005 | (827 km) (9:30) AHRPT |
| | METOP-2 | EUMETSAT | 01/2010 | (827 km) (9:30) AHRPT |
| | METOP-3 | EUMETSAT | 07/2014 | (827 km) (9:30) AHRPT |
| | FY-3A | China | 2006 | (9:30) series of seven satellites |
| | FY-3B | China | 2006 | (9:30) |
| | METEOR 3M-N2 | Russia | 2005 | (9:15) or (10:30) AHRPT |
| | METEOR 3M-N3 | Russia | 2008 | (10:30) or (16:30) AHRPT |
| | DMSP S-16 | USA/NOAA | 09/2003 | (19:54 A) (SSMI/S) |
| | DMSP S-18 | USA/NOAA | 10/2006 | (SSMI/S) |
| | NPP – NPOESS Preparatory Project | USA/NOAA/ NASA | 10/2006 | (833 km) (10:30 D) (VIIRS, CrIS, ATMS, OMPS) HRD |
| | NPOESS-1 | USA/NOAA | 11/2009 | (833 km) (9:30 D) LRD (AHRPT) HRD |
| | NPOESS-4 | USA/NOAA | 11/2015 | (833 km) (9:30 D) LRD (AHRPT) HRD |
| | Monitor-E | Russia | 2004 | (550 km) (10:30) Land Observing Satellite |
| | GOCE ( R ) | ESA | 02/2006 | 250 km (dawn-dusk) |
| | SMOS ( R ) | ESA | 02/2007 | 755 km (6:00 A) |
| | ADM ( R ) | ESA | 10/2007 | 405 km (18:00 A) |
| **Sun-synchr. "Afternoon" (12:00 – 16:00) (00:00 – 04:00)** | NOAA-N | USA/NOAA | 6/2004 | (14:00) |
| | NOAA-N' | USA/NOAA | 03/2008 | (14:00) |
| | NPOESS-2 | USA/NOAA | 06/2011 | (833 km) (13:30 A) LRD (AHRPT) |
| | NPOESS-5 | USA/NOAA | 01/2018 | (833 km) (13:30 A) LRD (AHRPT) |
| **Sun-synchr. "Early morning" ( 4:00 - 6:00) (16:00 – 18:00)** | DMSP-S17 | USA/NOAA | 10/2004 | (SSMI/S) |
| | DMSP-S19 | USA/NOAA | 10/2008 | (SSMI/S) |
| | DMSP-S20 | USA/NOAA | 10/2010 | (SSMI/S) |
| | NPOESS-3 | USA/NOAA | 04/2013 | (833 km) (5:30 D) LRD (AHRPT) |
| | NPOESS-6 | USA/NOAA | ~2019 | (833 km) (5:30 D) LRD (AHRPT) |

| Orbit type (equatorial crossing times) | Future additional Satellites R = R & D | Operator | Planned launch date | Other information |
|---|---|---|---|---|
| **Non Sun-synchr.** | Sich-1M | Russia/Ukraine | 2004 | (650 km) Oceanographic Satellite |
| | Resource-DK | Russia | 2005 | (350 km) Land Observing Satellite |
| | CRYOSAT | ESA | 09/2004 | 717 km |

### 2.2.3. Orbital Positions and Reconfiguration of the Space-based Component of the GOS

In 2002 WMO (CGMS XXX-WMO-WP-18) informed CGMS members of WMO activities related to the coordination of equator crossing times for polar orbiting satellites, and reiterated the need for CGMS satellite operators to provide updates on an annual basis. This information (see table 5.7) would serve as a useful reference for future mission planning in the polar orbit as well as for contingency planning. WMO highlighted the need to coordinate equator crossing times at the WMO Consultative Meetings on High Level Policy on Satellite Matters which met in Geneva in February 2002, which noted the complexity of the issue and realised that more in-depth analysis would need to be performed. However, it was unanimous in its belief that an optimised equator crossing time plan based on the totality of user requirements was essential.

Such an optimisation would also allow the development of contingency plans for the polar orbit. In June 2002, the fifty-fourth session of the WMO Executive Council (EC-LIV) was informed of the equator crossing time issue and noted that the basic WMO requirement for the polar orbit was for two satellites,  one in the AM orbit and one in the PM orbit. In order to meet WMO’s requirement for contingency planning a constellation of four polar-orbiting satellites would be required, two in the AM orbit, both capable of serving as back-up to the other and two in the PM orbit, again both capable of serving as back-up to the other. EC-LIV was pleased to note that both Roshydromet and CMA, taking into account their respective national requirements, would be willing to consider the possibility of using the PM orbit for their future Meteor-3M and FY-3 series.

# 3. DATA DISSEMINATION MISSIONS

## 3.1. CURRENT DISSEMINATION VIA GEOSTATIONARY SATELLITES

### 3.1.1. Introduction

Visible and infrared images generated by the geostationary meteorological satellites are transmitted and broadcast in several different ways and at different levels of quality, e.g.

- the direct broadcast of raw image data to a unique very sophisticated Central Station or to a limited number of sophisticated User Stations,

- the direct or re-broadcast of pre-processed high resolution digital image data to several hundred moderately sophisticated Data User Stations,

- the direct or re-broadcast of lower-resolution image data (or other meteorological data) to several thousand simple User Stations.

For the first two types of broadcast, each meteorological satellite operator has developed its own standard, meeting national requirements, and hence CGMS has, to date, not attempted to standardise these transmissions. However, at annual meetings, CGMS members are regularly kept informed on the status of each system, to the extent that contingency plans have been developed which would allow some exchange of high-resolution image data between neighbouring satellite systems, after suitable reformatting and retransmission through an appropriate ground relay station. An example of such a facility exists in Lannion, France, for the direct acquisition by EUMETSAT of GOES-East image data. These images are reformatted in Lannion and retransmitted to users in Europe and Africa via Meteosat. Indirect reception in Lannion of GOES-West and Japanese GMS images, either via regular telecommunications satellite or terrestrial links, allows the re-broadcast of a set of near global coverage images through one satellite system.

The third type of re-broadcast, called WEFAX, allows many thousands of users worldwide (mainly interested in the visual exploitation of images) to have easy access to image data and other meteorological information relayed by the satellite systems. The standard agreed by CGMS for WEFAX dissemination was based upon the APT transmission scheme adopted by the Russian and USA polar-orbiting satellite systems. In fact, WEFAX can be received by most existing APT Stations with relatively minor modification. Interest in the WEFAX service offered by the satellite operators has developed significantly over the last ten to fifteen years and there are a number of commercial and amateur manufacturers of WEFAX/APT ground stations world-wide. Lists of manufacturers and indications of the global use of WEFAX can be found on the WMO Web pages and can be provided by the satellite operators.

With the advance in technology and the desire by users for digital data, which can be manipulated on a PC without analogue to digital conversion and from which products can be derived, CGMS has agreed a new standard called Low Rate Information Transmission (LRIT). Details of the global specification for LRIT, together with mission specific details, can be found on the EUMETSAT and WMO Web pages and on those of many other satellite operators. The LRIT Global Specification can be found as a PDF document (reference CGMS03) in the publications/CGMS section of the EUMETSAT web site http://www.eumetsat.de. Further details can be found in WMO document SAT-19, Application and Presentation Layer Specifications for the LRIT/LRPT/HRIT/HRPT which is available as a Word format in the publications section of the Satellite Activities section of the WMO Web site http://www.wmo.ch.

The first direct HRIT and LRIT broadcasts were originally expected to be implemented by EUMETSAT, following the launch of its first Meteosat Second Generation (MSG) satellites in August 2002. However, following the failure of a solid state power amplifier on board MSG-1, there will be no direct HRIT/LRIT broadcast from this particular satellite. The MSG HRIT/LRIT broadcast will, instead, be implemented during 2003 using an Alternative Dissemination Mechanism, called EUMETCast, based upon the use of a commercial DVB broadcast satellite. Thus, the first direct LRIT broadcasts will be implemented in 2003 by Japan and USA, following the launches of MTSAT-1R and GOES-N, respectively.

The reader is invited to consult the EUMETSAT Web site www.eumetsat.de for more information on the EUMETCast Dissemination Service used to broadcast MSG HRIT and LRIT data.

In order to provide users of image data from geostationary meteorological satellites time to prepare for the transition from analogue WEFAX to digital LRIT broadcasts, and the consequential upgrade of User Stations, the satellite operators have agreed to maintain WEFAX broadcasts for two or three years following the introduction of LRIT services. This will normally be achieved by extending the period of operation of current satellite systems into the first few years of operation of the new generation of satellites. Schedules of broadcast transitions for individual satellite systems can be found at the WMO web site.

CGMS has expressed an interest in receiving broadcast INSAT and METSAT data on a real-time basis and India was asked to investigate the possibility of making such data available for retransmission to CGMS members. Towards this goal, the preparation and approval of the legal instrument between ISRO and EUMETSAT which could lead the way to reciprocal bilateral exchange of image data from the parties geostationary satellites in support of weather analysis and forecasting as well as climate research was achieved during 2000.

Regularly updated information on the data transmission schedules operated by the meteorological satellite operators can be found at the WMO web site, and those of the satellite operators.

### 3.1.2. High Resolution Image Dissemination

#### 3.1.2.1. EUMETSAT

The High Resolution Image (HRI) broadcast from first generation Meteosat satellites provides pre-processed digital image data, which is designed for further processing by the user. The broadcast has a data rate of 166.6 Kbits/second and standard corrections, including registration between image channels, calibration adjustment and rectification are applied to images before transmission.

Meteosat HRI data are broadcast in one of two standard formats. The A-Format covers the full earth disc and is transmitted every 30 minutes in various combinations of spectral channels and image resolution. The B-Format, again broadcast every 30 minutes, mainly covers the European sector and gives priority to visible and infrared channels. In addition, several X-Formats covering the full disc are used for digital imagery from foreign geostationary meteorological satellites. The E_X and W_X- Formats denote infrared or visible images from the USA GOES-E and GOES-W satellites, respectively. The J_X-Format is used for infrared or visible images from the Japanese GMS satellite.

Full details of Meteosat HRI image broadcasts can be found in EUMETSAT Document TD02 - Meteosat High Resolution Image Dissemination, which is available as a PDF publication from http://www.eumetsat.de. The latest broadcast schedules are available from the Operational Services area of the same site.

Reception of Meteosat HRI data using a Primary Data User Station (PDUS) gives the user almost immediate access to high quality image data covering most of the world. Being digital, the images are suitable for use with sophisticated processing techniques in local computer systems. Data covering the European sector (B-Formats) are available within 10 minutes from the end of image acquisition. Images covering Africa and the Middle East are transmitted within about 20 minutes of image acquisition and re-broadcasts of digital data from the GOES and GMS satellites are transmitted at least once every three hours, arriving at the user station within 30 minutes of the nominal image time.

Since September 1995, most Meteosat HRI data have been transmitted encrypted, however, six-hourly HRI images from the 0° Service Meteosat, at 00, 06, 12 and 18 UTC, are transmitted unencrypted. Therefore, in order to receive encrypted HRI data (GOES and GMS data are not encrypted), the user station has to be licensed with EUMETSAT and equipped with a decryption key unit, which is only available from EUMETSAT.

**Indian Ocean Data Coverage (IODC)**

Since the end of May 1998, Meteosat-5 has been located at 63°E where it supported INDOEX until the end of 1999 and will continue to support the IODC service until the end of 2005. Possibilities to extend this service by one or two more years are currently being studied. HRI broadcasts, on one channel only, comprise VIS, IR and WV formats. Some IODC formats are also included in the 0° Service broadcast. A sample of IODC HRI data can be found at: http://www.eumetsat.de.

### 3.1.2.2. India

There is currently no regular direct broadcast of INSAT high resolution image data outside continental India.

### 3.1.2.3. Japan

High resolution image dissemination is accomplished by the direct read-out of stretched VISSR (S-VISSR) data from GMS. There are 60 stations receiving high resolution data dissemination, called Medium-scale Data Utilisation Station (MDUS), including 37 stations located outside Japan (as of March 2003). Full details of GMS high resolution image dissemination can be found in the GMS User's Guide (third edition), which was published in 1997 and available from JMA.

### 3.1.2.4. PRC

High resolution image data from the S-VISSR instrument on board the FY-2 geostationary meteorological satellite are rebroadcast to Medium-scale Data Utilisation Station (MDUS). WEFAX and S-FAX (for domestic use only) data are retransmitted to Small-scale Data Utilisation Station (SDUS). The signal characteristics of FY-2 S-VISSR data are shown in the following table.

**Table 3.1.2.4. signal characteristics of FY-2 S-VISSR data**

| | |
|---|---|
| Frequency: | 1687.5MHz |
| Modulation: | PCM/BPSK, NRZ-M |
| Bit rate: | 660 Kb/s (fixed) |
| EIRP: | 57+1 dBm |
| Polarisation: | Linear |
| Bandwidth: | 2MHz |
| Data Volume: | 329,872 bits/line (including SYNC code) |
| Data Coding: | Byte complimenting and PN scrambling |

Since these signal characteristics are very close to those of the Japanese GMS satellite system, except for the transmit frequency, user stations capable of receiving Japanese GMS S-VISSR data can also receive FY-2 S-VISSR data by re-pointing the station antenna and adjusting the frequency of the receiver local oscillator. FY-2 S-VISSR images are also disseminated on the Internet. These images, together with more detailed information about the FY-2 satellite system can be found at http://www.cma.gov.cn.

### 3.1.2.5. Russia

There is currently no regular broadcast of GOMS High Resolution image data. For information about future GOMS satellites, please see section 3.2.1.5. Additionally, more detailed information about the GOMS satellite system can be found at http://sputnik1.infospace.ru/goms/engl/goms_e.htm.

### 3.1.2.6. USA

With its two operational satellites, the GOES system views North, Central, and South America and their neighbouring ocean environments including the central and eastern portions of the Pacific Ocean and the central and western portions of the Atlantic Ocean. Two primary instruments carry out the main mission. The Imager is a multi-channel instrument that senses radiant energy and reflected solar energy from the Earth's surface and atmosphere. The Sounder is a multi-channel instrument that provides data through vertical atmospheric temperature and moisture profiles, surface and cloud top temperatures, and ozone distribution. The instruments scan the Earth according to the sector commanded. Raw data from these instruments is down-linked to the ground to be processed into GOES I-M Variable (GVAR) formatted data. The GVAR data is up-linked to its corresponding GOES satellite, together with auxiliary data inputs from additional ground equipment, for global re-broadcast to users.

The GVAR data format is primarily used to transmit Imager and Sounder meteorological data. Other functions of GVAR data include transmission of calibration data, satellite navigation data, administrative and operational text messages. The GVAR format was developed because the AAA format used for the early spin-stabilised GOES spacecraft would severely limit the capabilities of the Imager and Sounder for the new three-axis stabilised spacecraft platform. The AAA format used a fixed-length transmission. The GVAR format supports variable scan line lengths.

Spare GOES satellites are stored in-orbit at 90W and 105W for use in the event of a failure on one of the operational spacecraft. Auxiliary meteorological services are also supported through the GOES satellites for hemispheric broadcast: Weather Facsimile (WEFAX) [being replaced by digital Low-rate Information Transmission in early 2003]; and Emergency Managers Weather Information Network (EMWIN). Data Collection System (DCS) platforms also transpond through the GOES satellites and their data is available to system participants via commercial satellite broadcast, dial-up, and Internet. GOES also supports transponding Search and Rescue Satellite Aided Tracing (SARSAT) signals from emergency locator beacons.

New on GOES-M (launched July 2001) is the Solar X-ray Imager (SXI) instrument, monitoring 'space weather.' SXI data is processed through the Space Weather Office in Boulder. Colorado and distributed via the Internet.

There are several Web sites that provide information on the GOES mission. These sites also provide links for additional information. A listing of these sites follows.

http://www.noaa.gov , http://www.nesdis.noaa.gov , http://www.oso.noaa.gov

http://www.goes.noaa.gov, http://www.ssd.noaa.gov, http://www.ncep.noaa.gov

http://www.ncdc.noaa.gov

### 3.1.3. Low Resolution (WEFAX) Image Dissemination

#### 3.1.3.1. EUMETSAT

Meteosat dissemination channel 1 (1691 MHz) is used for the dissemination of analogue (WEFAX) data. There are over 8000 stations receiving these data, and more than 80 national meteorological services are operating such stations.

The WEFAX dissemination system provides imagery in analogue format for qualitative use in simpler types of user stations. The rectified full disc images are cut into a number of smaller formats and transmitted to Meteosat for reception by the users. On a few occasions each day a full earth disc image, in reduced resolution, is also transmitted.

As well as the Meteosat imagery, the WEFAX dissemination schedule includes analogue imagery from the USA satellites (GOES-E and W), the Japanese and the Russian satellites.

More information about the WEFAX service can be found in Technical Document EUM TD 03 Meteosat WEFAX Dissemination, copies of which can be downloaded from the publications area of http://www.eumetsat.de.

Use is made of the gaps of about 27 seconds between each WEFAX format to re-broadcast DCP messages (see Chapter 4). These messages can be received directly by slightly modified WEFAX receiving stations. Full details of this service can be found in Technical Document EUM TD 04 Meteosat Data Collection and Retransmission System (DRS), copies of which can be downloaded from the publication area of http://www.eumetsat.de.

### 3.1.3.2. India

Processed low resolution cloud images are disseminated to user stations via INSAT using the C/S-band transponder on board the satellite, which is also used to broadcast TV signals. The images are in the form of amplitude modulated signals at 2.4 kHz and can be received all over India and some neighbouring countries using low cost satellite receivers. Along with the images, Fax charts of analysed data and conventional meteorological data are also transmitted after multiplexing all three types of data into the one broadcast. This scheme is known as Meteorological Data Dissemination and transmissions are currently in analogue form. Images are disseminated on a three-hourly basis for utilisation by operational forecast offices. Satellite cloud images are also disseminated on an hourly basis in the event of tropical cyclones/other disturbances in the Bay of Bengal and Arabian Sea. Characteristics of antenna footprints are such that signals can only be received in continental India and in some neighbouring countries, where a higher G/T specification is required for the receiving station. Latest satellite images can be accessed on IMD's Web site http://www.imd.ernet.in/main_new.htm.

### 3.1.3.3. Japan

WEFAX images from the GMS satellite are received by a total of 1038 stations, called Small-scale Data Utilisation Station (SDUS), including 128 stations located outside Japan (as of March 2003). Further information about GMS WEFAX can be found in the GMS User's Guide (third edition), which was published in 1997 and available from JMA.

### 3.1.3.4. PRC

WEFAX images are disseminated via the FY-2 series of satellites to Small Scale User Stations (SDUS) at a transmission frequency of 1691 MHz. The WEFAX transmission format is completely compatible with that of other geostationary meteorological satellites.

### 3.1.3.5. Russia

During the period of operation of the GOMS/Electro N1 geostationary satellite at 76° E (1994-1998), infra red images were regularly disseminated in WEFAX format at a transmission frequency of 1691 MHz. Full disk images together with four 10 degrees overlapping sectors from GOMS/Electro and certain images from the Meteor polar satellites were regularly disseminated via GOMS. The dissemination format and schedule has been widely distributed to users (reference PL/97-TD/GOMS0003).

In addition to the dissemination of WEFAX images via the satellite, similar images were placed, in real time, on SRC Planeta's Internet server http://sputnik1.infospace.ru, thereby allowing a wide group of users to have free access to operational low resolution GOMS imagery.

#### 3.1.3.6. USA

Weather Facsimile (WEFAX) is a communications transponder service provided through the GOES 8 and GOES 10 satellites. WEFAX involves the retransmission of low-resolution geostationary and polar orbiter satellite imagery or other meteorological data through the GOES satellites to relatively low cost receiving units within receiving range of the satellite. The low-resolution geostationary and polar satellite images are produced at the NOAA Central Environmental Satellite Computer System (CEMSCS) facility in Suitland, Maryland. This imagery is produced from the retransmitted GVAR (GOES variable data format) data streams received at the facility. The CEMSCS ingests these retransmitted GVAR data streams through a Front End Processor (FEP). Based on an automated schedule, the data is subset into sub areas, reduced in spatial resolution, if necessary, and enhanced according to predefined look-up tables. The resultant WEFAX products are referred to as sectors which are spatial subsets of the full earth disc corresponding to an area of interest to weather forecasters. The generated sectors are then transmitted from CEMCSC as analogue facsimile signals via dedicated telephone lines. This data is sent to the Wallops CDA station for transmission through the GOES spacecraft. For additional information on WEFAX, see http://noaasis.noaa.gov/NOAASIS, or http://iwin.nws.noaa.gov/wefax/index.htm.

## 3.2. Future Dissemination via Geostationary Meteorological Satellites

### 3.2.1. High Rate Information Transmission (HRIT)

#### 3.2.1.1. EUMETSAT

The reader should note that the MSG HRIT and LRIT data streams will not be broadcast from the first Meteosat Second Generation (MSG-1) satellite. MSG-2 will be launched in 2005. In the meantime, use will be made of an Alternative Dissemination Mechanism, called EUMETCast, and based upon commercial Digital Video Broadcast (DVB) satellites, to disseminate the HRIT and LRIT data files. Please see the EUMETSAT Web site www.eumetsat.de for further details on METEOCast and related publications.

The HRIT data stream itself comprises multiplexed image data from every channel of the SEVIRI instrument on board MSG. Because of the limited channel capacity, lossless data compression is applied to all SEVIRI channels (lossy JPEG for the High Resolution Visible (HRV) data in order to maximise the amount of information to be transmitted. For more information see the MSG Data, Products & User Services area of http://www.eumetsat.de.

The HRIT data stream has a capacity of 1 Mbit/s which allows the reception of the disseminated MSG level 1.5 image data in quasi real-time every 15 minutes and with full spatial resolution. The image data is segmented, encrypted and JPEG-compressed before transmission.

A primary objective of the HRIT service is to deliver image data for nowcasting within a few minutes of the end of acquisition of each image, therefore the timeliness of data delivery is an issue of utmost importance.

Access by the user to HRIT dissemination and MeteoCAST is controlled, according to EUMETSAT Data Policy, through the employment of encryption. HRIT data is received either via a High Rate User Station (HRUS) suitably modified to receive the MeteoCAST broadcast, or via a MeteoCAST receiving station.

Further information about HRIT and the design of reception stations can be found at http://www.eumetsat.de.

### 3.2.1.2. India

There is currently no High Rate Information Transmission from INSAT satellites.

### 3.2.1.3. Japan

JMA plans to launch the next Multi-functional Transport Satellite (MTSAT-1R) in the summer of 2003 as the first of the MTSAT series to succeed GMS-5 and, step by step, to introduce enhanced transmission systems called High Resolution Imager Data (HiRID) and HRIT.

The HiRID data consists of three segments, one compatible with S-VISSR, and two additional segments at the end part of the data format. The first additional segment is a 2-bit data stream used for the precise retrieval of IR images by merging the current 8-bit data with the S-VISSR data. The second additional segment is the IR4 channel (3.5-4.0μm) data. Therefore, a user who is unable to receive either the IR4 channel data or the 10 bits IR data can still receive and use HiRID data via an existing MDUS without modification.

It is planned to start the HRIT service in March 2005, allowing the dissemination of full resolution imagery to MDUS. HRIT and HiRID will be available for about three years, from March 2005, using the same frequency band and according to a time-shared broadcast schedule.

Details of HiRID data are given in “MTSAT HiRID Technical Information (Issue 3, 1 June 1999, JMA) and are also available from the WMO web site. For a complete description of HRIT, the reader is invited to consult “JMA HRIT Mission Specific Implementation (Issue - 1.2, 1 January 2003, JMA).

### 3.2.1.4. PRC

FY-2 B, C and D will have high rate information transmission S-VISSR, very similar to those of FY-2 A and B. Further details can be found at http://www.cma.gov.cn.

### 3.2.1.5. Russia

HRIT dissemination will be provided from the GOMS/Electro N 2, which is currently expected to be launched in 2005 and located at 76° E. The format specification of the GOMS HRIT will be widely distributed by the beginning of satellite operations.

### 3.2.1.6. USA

NOAA has initiated a program to introduce new advanced improved performance imager and sounder sensors to GOES satellites in years 2008 and 2010, respectively. The new imager has been named the Advanced Baseline Imager (ABI) and the sounder the Advanced Baseline Sounder (ABS). On receiving NOAA's requirements, NASA in support of NOAA released a competitive procurement for concept studies for new ABI design in late November 2000. Three contracts are likely to be awarded.

The ABI will have between 8-12 bands, with strong hopes for the 12 bands based on earlier NOAA engineering studies. The .59- .69 micron visible resolution band will be improved to 0.5KM with all other bands being 2km. The new imager-scanning rate will be significantly increased to provide 4 full discs per hour plus 12 CONUS scans.

The ABS will be a Michelson Interferometer providing a greater number of vertical layers and improved temperature and moisture accuracy. In addition the ABS will have a scanning rate approximately 4 times faster than the current sounder. This ABS scanning rate will in one hour cover not only CONUS but all of South America and a large open ocean area. in the Atlantic and in the Pacific beyond Hawaii.

The ABI and ABS from their increased capabilities will have a significantly higher data rate. The current processed rate of about 2.1Mbps will be somewhere in the range of 12-17Mbps. This will require significant changes to the GOES spacecraft communication system, some changes to the processed data sites, and the introduction of new data formatting. Because of the large data rate the GOES Variable Data Format (GVAR) would no longer be used.

**Table 3.2.1.6 ABI-8 bands through ABI-12 bands (in order of priority)**

| Wavelength (range) | Wavelength (centre) | Description | Use |
|---|---|---|---|
| 10.8 – 11.6 | 11.2 µm | IR Window 3 | Clouds, low-level water vapour, fog, winds |
| 0.59 – 0.69 | 0.64 µm | Solar Window | Daytime clouds, fog, aerosol, NDVI |
| 5.7 – 6.6 | 6.15 µm | Water Vapour 1 | Upper tropospheric flow, winds |
| 3.8 – 4.0 | 3. 9 µm | Short wave IR | Night-time low clouds, fog, fire detection |
| 11.8 – 12.8 | 12.3 µm | IR Window 4 | Low-level water vapour, volcanic ash |
| 13.0 – 13.6 | 13.3 µm | Carbon Dioxide | Cloud-top parameters, heights for winds |
| 6.8 – 7.2 | 7. 0 µm | Water Vapour 2 | Mid tropospheric flow, winds |
| 1.58 – 1.64 | 1.61 µm | Near IR | Daytime clouds/snow, water/ice clouds |
| 8.3 – 8.7 | 8.5 µm | IR Window 1 | Sulphuric acid aerosols, cloud phase, sfc |
| 10.1 – 10.6 | 10.35 µm | IR Window 2 | Cloud particle size, surface properties |
| 0.81 - 0.91 | 0.86 µm | Solar window | Day clouds, NDVI, fog, aerosol, ocean studies |
| 1.36 - 1.39 | 1.375 µm | Near IR | Daytime thin cirrus detection |
| If the 10.35 µm is not included, then the IR split window combination (10.1-10.6, 10.8-11.6, &11.8-12.8) should instead revert back to: | | | |
| 10.2 – 11.2 | 10.7 µm | IR Window 3 | Clouds, low-level water vapour, fog, winds |
| 11.5 – 12.5 | 12.0 µm | IR Window 4 | Low-level water vapour, volcanic ash |

### 3.2.2. Low Rate Information Transmission

Details of the global specification of LRIT can be found on the WMO Web site and those of some other satellite operators.

#### 3.2.2.1. EUMETSAT

The reader should note that the MSG HRIT and LRIT data streams will not be broadcast from the first Meteosat Second Generation (MSG-1) satellite. MSG-2 will be launched in 2005. In the meantime, use will be made of an Alternative Dissemination Mechanism, called EUMETCast, and based upon commercial Digital Video Broadcast (DVB) satellites, to disseminate the HRIT and LRIT data files. Please see the EUMETSAT web site www.eumetsat.de for further details on METEOCast and related publications.

The LRIT data stream itself comprises multiplexed image data from 5 channels of the SEVIRI instrument on board MSG. Also included is some foreign satellite image data, meteorological products and DCP data, within the limits of the defined data rate. The LRIT data rate is 128kbit/s. Lossy compression is applied to all images (compression factor close to 8). Images have full spatial resolution with image data rounded to 8 bits. Images are received via LRIT every 30 minutes.

Further details of the EUMETSAT LRIT broadcast and the necessary reception equipment can be found at http://www.eumetsat.de.

### 3.2.2.2. India

Currently no LRIT broadcasts are foreseen from INSAT satellites

### 3.2.2.3. Japan

JMA plans to introduce LRIT broadcasts with the launch of MTSAT-1R. LRIT will become operational by the end of 2003, and this digital transmission service will provide cloud imagery to SDUS. Both the LRIT and WEFAX services will be available until March 2005 via the same frequency band and according to a time-sharing broadcast schedule. Specifications of the imagery via LRIT are as shown in the following table.

**Table 3.2.2.3 Specifications of the imagery via LRIT from MTSAT-1R**

| Area (projection) | Channels* |
|---|---|
| Full disk (normalised geostationary projection) | IR1, IR3 |
| East Asia (polar stereographic projection) | VIS, IR1, IR3, IR4 |
| Northeast Japan (polar stereographic projection) | VIS |
| Southwest Japan (polar stereographic projection) | VIS |

Channels* : IR: Infrared ; VIS: Visible

VIS and IR images are composed of 6 bits and 8 bits, respectively.

Further details can be found in document "MTSAT LRIT Mission Specific Implementation (Issue 6, 1 January 2003, JMA).

### 3.2.2.4. PRC

It is foreseen that the FY-2 C, and D satellites will provide LRIT broadcasts, the format being similar to that of MTSAT.

### 3.2.2.5. Russia

The dissemination of LRIT data is planned following the launch of GOMS/Electro N 2 (currently expected in 2005. The GOMS LRIT format will follow CGMS global specifications and a technical description will be widely distributed by the beginning of satellite operations.

### 3.2.2.6. USA

The USA has developed a transition and implementation plan for the LRIT that will commence on a GOES I-M spacecraft other than the operational satellites. Using the GOES-M spacecraft, LRIT testing was conducted from October 2002 – October 2003. Test schemes included variations of alternate transmissions of simulated LRIT signals with WEFAX and/or EMWIN broadcasts.

Testing of the LRIT Product Processing System live through the GOES-12 satellite ended on October 7th after completing a seventh week successfully. The tests were conducted so as not to impact the current WEFAX operations, as such, LRIT transmitted only during two open periods in the WEFAX schedule. NOAA's LRIT data began operational transmission, on October 7th at 00Z, in a timesharing mode with WEFAX

NOAA plans to do timesharing between WEFAX and LRIT on individual spacecraft for a limited time period (e.g., 1 to 2 years) followed by a total transition. The transition from existing WEFAX services to the new LRIT services has considered the requirements and concerns of the existing user population as well as the availability of NOAA resources (e.g., satellites, ground communications and control systems, personnel).

**SYSTEM TRANSITION AND TESTING PLANS**

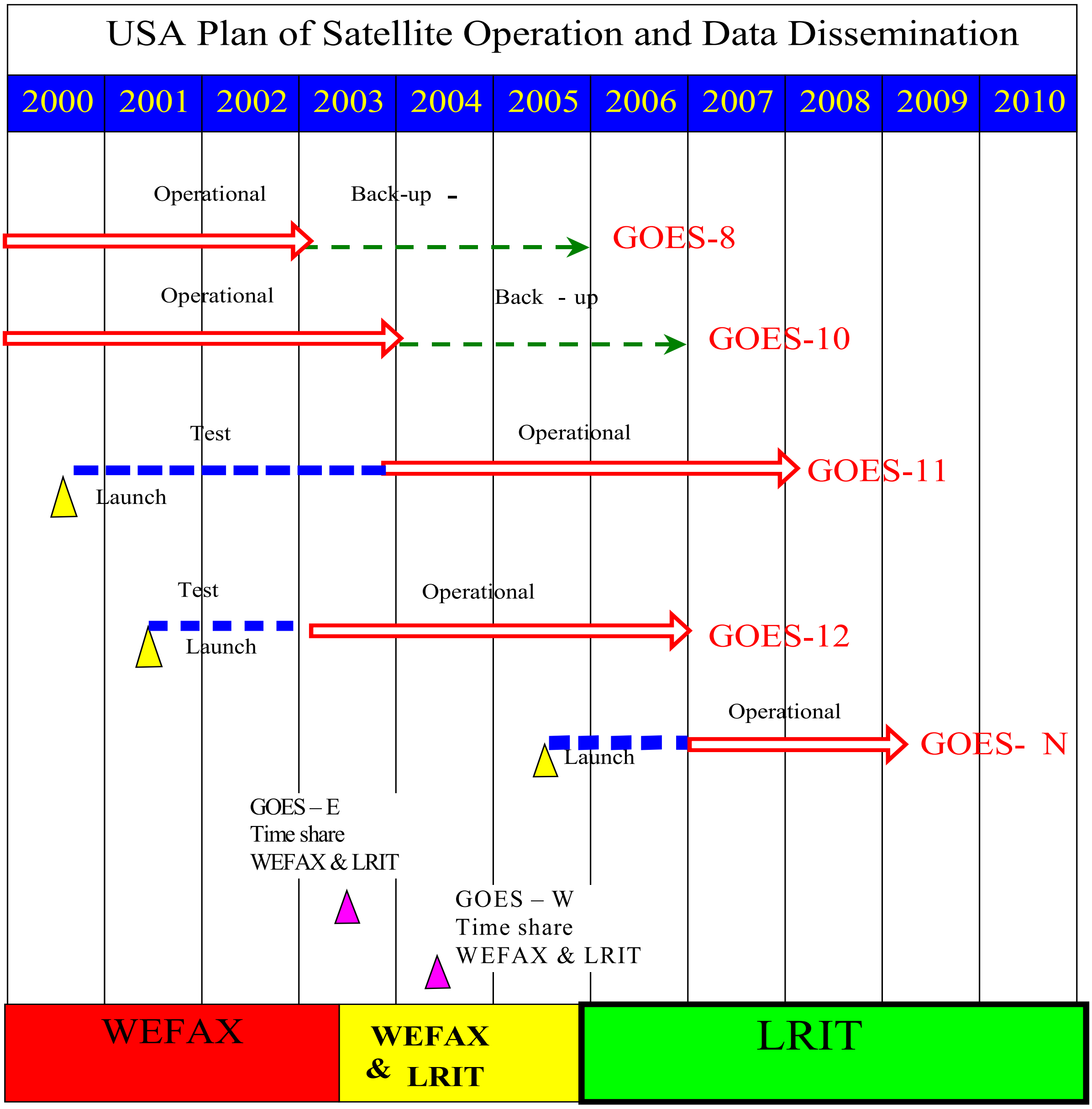
During the transition period, the USA will require the use of a GOES I-M spacecraft. The new ground equipment at the Wallops CDA stations and the LRIT test schedules allow an orderly transition to LRIT without the need to be sensitive to the specific GOES-N launch date.

Further, the LRIT transition is described as a period of parallel operations for each of the two GOES satellites where both WEFAX and LRIT services would be simultaneously broadcast (i.e., timeshared GOES I-M transponder) for a specified transition period, followed by a full and permanent transition to full LRIT services. Currently, using the GOES-East (GOES-12) satellite, NOAA's LRIT data transmissions are scheduled and taking place daily from [HH:45 to HH+1:14] and WEFAX data from [HH:14 to HH:45].

A goal of the transition plan is to provide the capability for an extended transition period without imposing significant demands for additional space, ground, and personnel resources. Current assessments of NOAA's plan are encouraging in the ability of the GOES I-M series to simultaneously accommodate both WEFAX and LRIT data through timesharing techniques.

The current plans for LRIT implementation and transition testing is as follows:

- Initial ground testing of simultaneous LRIT and existing EMWIN transmissions were positive (i.e., acceptable performance) at the 128 kbps data rate.
- Timesharing using GOES –12 (east) in place since October 2003 and will continue for at least a year. LRIT only transmissions should begin the end of 2004.
- Timesharing using GOES – West is planned to start the 2nd quarter of 2004.
- Full LRIT only (no WEFAX) is planned to begin late 2005.




The latest plans and information regarding the NOAA LRIT project can be found on the Web at http://noaasis.noaa.gov/NOAASIS/ml/LRIT.html.

### 3.3. CURRENT DISSEMINATION VIA POLAR-ORBITING METEOROLOGICAL SATELLITES

#### 3.3.1. High Resolution image dissemination

##### 3.3.1.1. EUMETSAT

EUMETSAT currently does not operate polar-orbiting meteorological satellites.

##### 3.3.1.2. India

India currently does not operate polar-orbiting meteorological satellites.

#### 3.3.1.3. Japan

JMA currently does not operate polar-orbiting meteorological satellites.

#### 3.3.1.4. PRC

The High Resolution Picture Transmission of FY-1 C and D is named CHRPT and can be received by other countries without restriction. In addition to CHRPT there is a Delayed Picture Transmission (CDPT) for the broadcast of 4 channel global image data with 4km resolution. Whilst CHRPT is disseminated world-wide, the CDPT is only received within China.

The data format of CHRPT is similar to the HRPT format provided by the US NOAA satellites and the transmission characteristics of CHRPT can be found at http://www.cma.gov.cn.

**Table 3.3.1.4. Transmission characteristics of CHRPT**

| | |
|---|---|
| Transmission frequency | 1700.5 MHz, 1704.5MHz as backup |
| Transmission frequency | 1708.5 MHz, 1695.5 MHz as backup |
| EIRP | 39.4dbm |
| Polarisation | right hand circular |
| Modulation | PCM-PSK |
| Modulation index | 67.5° ±7.5° |
| Bit rate | 1.3308 Mbps |
| Number of words in frame | 22180 |
| Number of channels | 10, 2048 words/channel |
| Rate of frame | 6 frames/second |
| Number of bits of word | 10 bits/word |
| Rate of bit | 1.3308 Mbps |
| Bit format | split phase |

#### 3.3.1.5. Russia

There is currently no HRPT direct broadcast from Russian polar-orbiting meteorological satellites. Such broadcasts are planned with the launch of the next satellite in the Meteor series, currently foreseen by 2005 (see section 3.4.1.5).

Data from Meteor-3M N1 satellite (launched 10/12/2001), including data from the Scanning IR “Klimat” and visible “MR-2000M” radiometers, MW atmospheric sounder “MTVZA”, MW radiometer “MIVZA” as well as from the NASA Stratospheric Aerosol and Gas Experiment-III instrument “SAGE-III” are received in the Main Acquisition Centres of Roshydromet in Moscow (SRC Planeta) and Novosibirsk. The satellite commissioning tests are under way.

### 3.3.1.6. USA

The High Resolution Picture Transmission (HRPT) system provides data from all spacecraft instruments at a rate of 665,400 b/sec. The S-band real time transmission consists of the digitised unprocessed output of five Advanced High Resolution Radiometer (AVHRR) channels, plus the TIP (HIRS, SBUV, SEM, DCS instruments) data and Advanced Microwave Sounding Unit (AMSU) instrument data. (AMSU is available only on NOAA-15 and later spacecraft.) All information necessary to calibrate the instrument outputs is also included in the data stream. Transmission characteristics can be found at http://www2.ncdc.noaa.gov/docs/klm.

**Transmission characteristics**

The S-band transmission of time multiplexed, digital data is in a split phase format. Table 3.3.1.6.1 shows the general characteristics of the HRPT transmission system, while the general HRPT parameters are shown in Table 3.3.1.6.2.

**HRPT Minor Frame Format**

The Manipulated Rate Information Processor (MIRP) outputs the HRPT format simultaneously with the Automatic Picture Transmission (APT), Global Area Coverage (GAC) and Local Area Coverage (LAC) formats. GAC and LAC data are not considered real time, as these data are stored on the spacecraft digital recorders for readout by the CDA stations and not available to direct readout users. The HRPT data format consists of a major frame, which is sub-divided in three minor frames. On NOAA-15 and later spacecraft, TIP and AMSU data are updated at the major frame rate. That is, the three minor frames, which make up the major frame will contain TIP data in the first minor frame, backfill in the second minor frame, and AMSU data in the third minor frame. In the previous series of satellites (NOAA E-J), the major frame consisted of three minor frames of only the TIP data.

**Table 3.3.1.6.1 Characteristics of HRPT Transmission System**

| | |
|---|---|
| Line Rate | 360 lines/minute |
| Data Channels | 5 transmitted,<br>6 available (NOAA-15 and later) |
| Data Resolution | 1.1 km |
| Carrier Modulation | Digital split phase, phase modulated |
| Transmitter Frequency (Mhz) | 1698.0 or 1707.0 primary, 1702.5 secondary |
| Transmitter Power (EOL) | 6.35 watts (38.03 dBm) |
| Radiated Power (dBm, @ 63 degrees) | 40.13 |
| Polarisation | RCP |

**Table 3.3.1.6.2 HRPT Parameters**

| | |
|---|---|
| Major Frame<br>Rate<br>Minor Frames/Major Frame | <br>2 major frames/sec<br>3 |
| Minor Frame<br>Rate<br>Number of words | <br>6 minor frames/sec<br>11090 |
| Word Parameters<br>Rate<br>Number of bits/word<br>Order | <br>66540 words/sec<br>10<br>Bit 1=MSB Bit 10=LSB |
| Bit Parameters<br>Rate<br>Format<br>Data "0"<br>Data "1" | <br>665400 Bits/sec<br>Split phase<br>+68/-68 degrees<br>-68/+68 degrees |

### 3.3.2. Low Resolution Picture Transmission (APT)

#### 3.3.2.1. EUMETSAT

EUMETSAT currently does not operate polar-orbiting meteorological satellites.

#### 3.3.2.2. India

India currently does not operate polar-orbiting meteorological satellites.

#### 3.3.2.3. Japan

JMA currently does not operate polar-orbiting meteorological satellites.

#### 3.3.2.4. PRC

There is no APT broadcast available from FY-1C.

#### 3.3.2.5. Russia

Visible images from the MR-900 scanning instrument (resolution 2 km, swath width 2600 km, spectral band 0.5-0.7 μm) are currently disseminated from Meteor-3 N5 (launched 15/08/91) satellite in APT mode. The characteristics of the transmitted signal remain as the following: carrier frequency – 137.85 MHz, modulation – FM, allocated bandwidth – 100 KHz, radio transmitter output power – 5W.

Until recently low resolution MR-900 visible images were also disseminated in APT mode from Resurs-O1 N 4 (since July 1998 up to November 2001). Active and passive microwave data and visible images (simultaneous frame of SLR, RM-0. 8 and MSU-M instruments) were disseminated in APT format from Okean-01 N 7 (since October 1994 up to May 2001) and Okean-O (since July 1999 up to February 2002) satellites.

Orbital data for these satellites, needed for direct readout of APT data, are distributed via the GTS in «ORBIT» code (WMO bulletin September - October 1997). Dissemination schedules are placed on the SRC Planeta Internet server http://sputnik1.infospace.ru.

### 3.3.2.6. USA

The Automatic Picture Transmission (APT) system provides a reduced resolution data stream from the AVHRR instrument. Any two of the AVHRR channels can be chosen by ground command for processing and ultimate output to the APT transmitter. A visible channel is used to provide visible APT imagery during daylight, and one IR channel is used constantly (day and night). A second IR channel can be scheduled to replace the visible channel during the night time portion of the orbit. The analogue APT signal is transmitted continuously and can be received in real time by relatively unsophisticated, inexpensive ground station equipment while the satellite is within radio range. The characteristics of the transmitted signal remain unchanged in the NOAA KLM satellite series from those in the TIROS-N series (NOAA 8 through NOAA 14), while there is a minor change in the data format to account for the modified channel 3 on the AVHRR/3 instrument beginning with NOAA-K. APT transmission characteristics can be found at http://www2.ncdc.noaa.gov/docs/klm.

**APT transmission characteristics**

The processed AVHRR instrument data AM modulates a 2400 Hz sub-carrier. The AM modulated sub-carrier is subsequently used to FM modulate the VHF APT transmitter operating in the 137 - 138 Mhz band. Table 3.3.2-1 summarises APT transmission characteristics.

**Table 3.3.2.6 APT Transmission Characteristics**

| | |
|---|---|
| Line Rate | 120 lines/min |
| Data Channels | 2 transmitted<br>6 available |
| Data Resolution | 4.0 km |
| Carrier Modulation | 2.4Khz AM sub-carrier on FM carrier |
| Transmitter Frequency (Mhz) | 137.50 or 137.62 |
| Transmitter Power (EOL) | 5 watts (37dBm) |
| Radiated Power (dBm, @ 63 degrees) | 36.7 |
| Polarisation | RCP |

**APT data frame format**

The MIRP processes the AVHRR data and outputs the APT format (simultaneously with the HRPT, LAC and GAC formats). All the processing in the MIRP is done in the digital realm. The digitised AVHRR input consists of 10-bit words. The MIRP inserts calibration and telemetry data for each of the selected APT channels being transmitted, and AM modulates the 2400 Hz sub-carrier, corresponding to the light and dark areas seen by the instrument, with the 8 Most Significant Bits (MSB) of the 10-bit data. The formatted data passes through the MIRP digital-to-analogue converter, is filtered and modulated onto the 2400 Hz carrier.

Two of all possible AVHRR spectral channels are multiplexed so that channel A APT data is obtained from one spectral channel of the first AVHRR scan line, and channel B from another spectral channel contained in the second AVHRR scan line. The third AVHRR scan line is omitted from the APT, and the process is then repeated. The data processing algorithm is designed so that the data maintains nearly equal geometric resolution of 4 km along the scan line. The two AVHRR channels used are identified in the daily TBUS message, and are further classified by the daytime and night-time portion of the orbit. Channel identification is also included as part of the telemetry frame.

**Table 3.3.2.6 APT Parameters**

| | |
|---|---|
| Frame<br>Rate<br>Length | <br>1 frame/64 sec<br>128 lines |
| Line Parameters<br>Rate<br>Number of words<br>Number of sensor channels<br>Number of words/sensor channel | <br>2 lines/sec<br>2080<br>2<br>909 |
| Word parameters<br>Rate<br>D/A conversion accuracy | <br>4160 words/sec<br>8 MSB's of each 10 bit word |

### 3.3.3. USA Direct Sounder Broadcast

The Direct Sounder Broadcast (DSB, also referred to as the beacon transmission) contains the low bit rate instrument (HIRS, SBUV, SEM, and DCS) digital data, identical to that within the HRPT transmission. These data are therefore available in both the VHF and S-band links. Those users receiving the high resolution HRPT transmission would likely find it most desirable to extract the low rate data from this data stream. The VHF beacon transmission is available to users who do not intend to install the more complex equipment necessary to receive high data rate S-band service. The lower data rates permit the user to install less complex, less costly equipment to receive the data without degrading its quality. For additional information on the Direct Sounder Broadcast (DSB), see http://www2.ncdc.noaa.gov/docs/klm.

**DSB Transmission Characteristics**

On board the satellite, output from the low data rate instruments is collected and formatted by the TIROS Information Processor (TIP). Parallel outputs are provided for the real-time VHF beacon transmission (DSB) and the MIRP (for the HRPT service). The instrument data is multiplexed with analogue and digital housekeeping data. The TIP output directly modulates the beacon transmission. The data is transmitted as an 8.32 Kbps split phase signal (similar to the HRPT transmission, above) over one of the beacon transmitters (BTX). Detailed transmission characteristics and TIP parameters are shown in Tables below.

**Table 3.3.3.1 DSB Transmission Characteristics**

| | |
|---|---|
| Carrier Modulation | Digital split phase, phase modulated |
| Transmitter Frequency (Mhz) | 137.35 or 137.77 |
| Transmitter Power (EOL) | 1.0 watts (30dBm) |
| Radiated Power (dBm) | ⊇ 9.5 (over 90% of sphere) |
| Polarisation | RCP |

**Table 3.3.3.2 TIP Parameters**

| | |
|---|---|
| Major Frame<br>Rate<br>Minor Frames/Major Frame | <br>1 major frame/32 secs<br>320 |
| Minor Frame<br>Rate<br>Number of words<br>Format | <br>10 minor frames/sec<br>11090<br>See Table 4.3.2-3 |
| Word Parameters<br>Rate<br>Number of bits/word<br>Order | <br>1040 words/sec<br>8<br>Bit 1=MSB Bit 8=LSB |
| Bit Parameters<br>Rate<br>Format<br>Data "0"<br>Data "1" | <br>8320 Bits/sec<br>Split phase<br>-67/+67degrees<br>+67/-67degrees |

### 3.3.4. NOAA Information Resources For Direct Readout Users

With the launch of NOAA-15, NOAA prepared the "NOAA-KLM User's Guide." The Guide includes detailed descriptions of all the instruments, all data transmission formats, data calibration techniques and similar information necessary for direct readout users. The User's Guide combines and replaces several older documents that were previously available from NOAA. The "NOAA KLM User's Guide" is available on the Internet at http://www2.ncdc.noaa.gov/docs/klm/.

***The Guide is also available on a CD-ROM. On this CD-ROM, you will find the" NOAA KLM User's Guide" as well as actual images and digital data samples obtained from NOAA-15. The samples will help in understanding the data formats and develop data processing software. Data samples and images are not available on the Internet version of the Guide.***

The Guide is available for a nominal charge (US $15.00) and must be ordered from the "online Store" at the NOAA National Climatic Data Center, http://www.ncdc.noaa.gov/.

POES operational information that is essential to operators of direct readout stations is provided through the NOAASIS website, http://noaasis.noaa.gov/NOAASIS. Included in the information available at the NOAASIS are the daily TBUS navigation bulletins, spacecraft transmission frequencies, changes to daily spacecraft operations, instrument data calibration coefficients, NOAA sea surface temperature algorithms, a limited number of online publications and satellite-related links throughout NOAA.

An introduction to NOAA satellite direct readout is contained in the "User's Guide for Building and Operating Environmental Satellite Readout Stations," which emphasizes low cost APT and WEFAX receivers. This publication is available upon request by sending an Email with the users complete postal address to: satinfo@noaa.gov.

## 3.4. FUTURE DISSEMINATION VIA POLAR-ORBITING METEOROLOGICAL SATELLITES

### 3.4.1. High Resolution Picture Transmission

#### 3.4.1.1. EUMETSAT

EUMETSAT is currently preparing the European component of a joint European/US polar satellite system. EUMETSAT plans to assume responsibility for the "morning" (local time) orbit and the US will continue with the "afternoon" coverage. It is planned to carry EUMETSAT instruments on the Metop satellite, developed in cooperation with ESA, the first to be launched in mid 2005. Metop-1 will be the first of a series of 3 operational polar-orbiting meteorological satellites providing service well into the second decade of the 21st century.

Real-time data access to Metop data will be achieved through a data transmission system. The Metop satellites will broadcast two data streams (Advanced High Resolution Picture Transmission and Low Resolution Picture Transmission - AHRPT and LRPT) continuously to user stations worldwide. By this means users will receive local data in real-time from the satellite each time it passes overhead or close to the station. The orbit is such that most recipients can expect to gather high resolution regional data extending up to about 1500 km radius of the user station, receiving images and other information from at least three consecutive orbits twice each day.

The AHRPT and LRPT data streams will be coordinated with those of the NOAA satellites, but due to evolving technology and different phasing of the systems the transmission details will differ. Metop will use a state-of-the-art packetised data transmission standard conforming to the recommendations of the Consultative Committee for Space Data Systems (CCSDS) and to global and mission specific specifications. For the time being, the NOAA satellites will continue to use their current transmission standards. As a consequence, users of Metop direct broadcast transmissions will need new frame synchronisers, reception hardware and software packages for data ingest.

The Metop Advanced High Resolution Picture Transmission (AHRPT) system will provide data to somewhat sophisticated user stations. This system will carry data from all Metop instruments, including those provided by the USA, but will ***not*** be compatible with the broadcast system of the same name currently flown on NOAA satellites.

The Metop Low Resolution Picture Transmission (LRPT) system will provide data to relatively simple user stations and will be the long-term replacement, using digital technology, for the analogue Automatic Picture Transmission (APT) system, currently used on NOAA satellites.

### 3.4.1.2. India

India currently has no plans to operate polar-orbiting meteorological satellites.

### 3.4.1.3. Japan

JMA currently has no plans to operate polar-orbiting meteorological satellites.

### 3.4.1.4. PRC

FY-1 D will have the same CHRPT as FY-1C. The high rate picture transmission of FY-3 has not been decided.

### 3.4.1.5. Russia

High resolution data from the next series of Meteor satellites (first launch is planned in 2005) will be disseminated using the 1.7 GHz frequency band in an HRPT compatible format. The format structure as well as data rate will be similar to NOAA HRPT. Format specifications will be distributed by the beginning of satellite operations.

### 3.4.1.6. USA

The National Polar-orbiting Operational Environmental Satellite System (NPOESS) development and acquisition plan is designed to make best use of production and existing POES and DMSP assets, to reduce risk on critical sensor payloads and algorithms, and to leverage civil, governmental, and international payload and spacecraft developments. In 1997, the NPOESS Integrated Program Office (IPO) initiated a robust sensor risk reduction effort that has been focused on early development of the critical sensor suites and algorithms necessary to support NPOESS. In 2000, the IPO initiated a program definition and risk reduction contract to define the requirements for total system architecture, including space, ground, and communications components, as well as to develop specifications for sensor/spacecraft integration.

During 2001, the IPO and the National Aeronautics and Space Administration (NASA) Goddard Space Flight Centre (GSFC) continued development of the joint IPO/NASA NPOESS Preparatory Project (NPP). With a planned launch in December 2005, this mission will support risk reduction opportunities for the critical NPOESS instruments of VIIRS, CrIS, and ATMS, as well as support demonstration, test, and evaluation of the NPOESS Integrated Data Processing Segment (IDPS) Environmental Data Record (EDR) processing software. Several of the major Command, Control, and Communication (C3) segment and Data Routing and Retrieval (DRR) features for NPOESS are required for the NPP mission as well. NPP will have a 15.0 Mbps real-time high rate data (HRD) broadcast at 7800 MHz.

With a planned launch of the first NPOESS spacecraft in early 2009, NPOESS will provide significantly improved operational capabilities and benefits to satisfy the critical civil and national security requirements for space-based, remotely sensed environmental data. The IPO will also populate a third orbital plane with an NPOESS spacecraft, thus providing 4-hour global VIIRS and CMIS imagery EDRs to the user community. NPOESS spacecraft will occupy 0530, 0930 and 1330 nodal crossing times. These activities represent a sound beginning for achieving the planned national and international programs in the new millennium and ensuring continuous support to a variety of users.

The total rate at which data will be generated by the NPOESS spacecraft is expected to be more than twenty times the rate for the current Polar-orbiting Operational Environmental Satellite (POES) and Defence Meteorological Satellite Program (DMSP) satellites, and will be formatted according to current Consultative Committee for Space Data Systems (CCSDS) conventions. Because of these significantly higher data rates, NPOESS will require equally significant increases in the bandwidth required for the communications links. Regulatory constraints on the current spectral allocations for POES and DMSP, as well as constraints on power spectral density have significant impacts on the trade space for the high rate data (HRD) and low rate data (LRD) for the NPOESS real-time direct broadcast services. The HRD broadcast link will provide data from all of the NPOESS instruments at "full quality" at a data rate of about 20 Mbps, and will require a bandwidth of nearly 50 MHz, with a receive antenna aperture not to exceed 2.0 meters in diameter. Because of the higher bandwidth requirement, the legacy spectrum at L-band is not sufficient to support the HRD broadcast for NPOESS. The IPO has reviewed alternative spectrum availability and has determined that the WRC-97 Meteorological-satellite (space-to-Earth), non-geostationary only allocation at 7750-7850 MHz would be suitable for this application.

### 3.4.2. Low Resolution Picture Transmission

#### 3.4.2.1. EUMETSAT

Please see paragraph 3.4.1.1. Further details can be found in the document CGMS 04 CGMS LRPT/AHRPT - Global Specifications, in the Publications area of : http://www.eumetsat.de.

#### 3.4.2.2. Japan

JMA has no plans to operate polar-orbiting meteorological satellites.

#### 3.4.2.3. PRC

There will be no LRPT broadcast available from FY-1D.

#### 3.4.2.4. Russia

Low resolution visible images are planned to be transmitted in LRPT format in the 137-138 MHz band from the next satellite in the Meteor series (launch planned for 2005). Meteor LRPT formats will follow CGMS global specifications and a technical description will be distributed by the beginning of satellite operations.

### 3.4.2.5. USA

Beginning with the NPOESS era, NOAA will broadcast a data rate much higher than the POES APT and the METOP LRPT. The NPOESS LRD broadcast link will provide data at a rate of 3.5 Mbps with full CCSDS convolutional coding, Viterbi decoding, and Reed Solomon encoding/decoding. This data rate is about forty times the current POES and DMSP LRD rates. With improved data compression on NPOESS, the LRD link is expected to provide significantly better quality imagery.

The NPOESS LRD broadcast content is selectable by ground command from the NPOESS Mission Management Center (MMC). The NPOESS LRD data stream design has been optimized to be flexible and support changing customer needs. Owing to the CCSDS packet structure for all NPOESS data and organization of that NPOESS data into application IDs (APID), discrete instruments and discrete instrument channels are selectable by ground command from the NPOESS Mission Management Center (MMC). The NPOESS spacecraft is generating data @ 20.0 Mbps and LRD is constrained to 3.5 Mbps. LRD data content priority was given to soundings and imagery. This means that the LRD data stream will be comprised mainly of data from the following instruments: Crosstrack Infrared Sounder (CrIS), Conical Microwave Imager/Sounder (CMIS) and selected Visible/Infrared Imager/Radiometer Suite (VIIRS) channels. The NPOESS LRD broadcast will occupy the legacy POES spectrum between 1698-1710 MHz.

## 3.5. DISSEMINATION OF SATELLITE DATA VIA THE GTS AND INTERNET

### 3.5.1. Introduction

The Global Telecommunication System (GTS) of the WMO, with its worldwide extension and high capacity, provides an excellent means for the further dissemination of meteorological satellite information and products. Four tasks have been identified which can be implemented effectively by means of the GTS. These are:

- dissemination of meteorological products derived from satellite imagery
- dissemination of DCP reports
- relay of administrative messages
- relay of basic meteorological data

Except for the last function, where bilateral arrangements are necessary, agreement has been reached between the satellite operators and WMO on the role of the GTS with regard to the distribution of information from meteorological satellite systems.

Increasingly, use is being made of the Internet to distribute satellite data and messages to individual or selected groups of users (an Internet based MSG data dissemination service is currently being planned by EUMETSAT). Access is usually password controlled and several operators for the distribution of processed imagery regularly use the system where image file sizes have to remain modest and compatible with the capacity of the Internet. The Internet can also be used for the near real time distribution of messages from data collection platforms. Messages can be "pushed" to the user according to an agreed schedule or the user can access his data on an as required basis.

### 3.5.2. Dissemination of Meteorological Products

The satellite operators or associated meteorological services derive many meteorological parameters from satellite image data, e.g. cloud motion winds, sea surface temperatures, cloud analysis, upper tropospheric humidity, etc. Each satellite processing centre disseminates products in a standard WMO code form on a regular basis to various meteorological centres. The data are used for the preparation of analysis charts and as input to the analysis schemes of numerical forecast models. List of products distributed and WMO codes used for them by each operator can be found in satellite operator Web pages.

#### 3.5.2.1. EUMETSAT

Many meteorological products are derived from Meteosat images. They are then sent in near-real time to the meteorological user community, where they support the quantitative use of Meteosat data in a wide range of applications. Products routinely extracted and broadcast are:

**Cloud Motion Winds (CMW)**

The Cloud Motion Winds product is generated by applying a correlation algorithm to sequences of three images (VIS in half resolution). By tracking the movement of cloud fields, winds can be extracted. The winds are derived for all three spectral channels as the Intermediate CMW Product, and an AQC Quality Index (QI) is assigned to every wind. However, the final CMW product only includes winds with a QI greater than a threshold value, only the best wind for each segment determined from the QI value, and there are also another limitations specified here. A typical product will contain up to 750 winds per channel. The product is distributed for the synoptic hours of 00, 06, 12 and 18 UTC in SATOB code.

**Expanded Low-resolution Winds (ELW)**

The ELW product is generated from the same Intermediate CMW Product (see above), and consists of all winds from all channels with a QI greater than an AQC threshold considerably lower than the AQC threshold for the CMW product. The ELW product is generated every 1.5 hours and distributed in BUFR code, and contains typically about 4000 winds.

**High Resolution Visible Winds (HRV)**

The High Resolution Visible Winds product is generated using essentially the same algorithm as the CMW product, but applied to the VIS images in full resolution. AQC is applied, and a typical product will contain up to 2000 winds. The product is generated for the synoptic hours of 06, 09, 12, 15 and 18 UTC and distributed in BUFR code.

**Clear-sky Water Vapour Winds (WVW)**

The Clear-Sky Water Vapour Wind product is generated using essentially the same algorithm as the other wind products, but tracking structures in the WV image from non-cloudy areas. AQC is applied, and a typical product will contain about 500 winds. The product is generated every 1.5 hours, and distributed in BUFR.

**High Resolution Water Vapour Winds (HWW)**

The High Resolution Water Vapour Wind product is generated using essentially the same algorithm as the CMW product, but the WV images are divided into sub-areas of 16x16 pixels, i.e. the same resolution as the HRV product. Only segments where a cloud has been detected are processed. AQC is applied and the product is generated every 1.5 hours, and distributed in BUFR.

**Sea Surface Temperatures (SST)**

For every segment where the sea surface is visible from geostationary orbit a temperature value is generated. This excludes land segments, and those segments with continuous cloud cover during the period of observation. A typical product contains around 1200 segment values. The product is generated twice daily, for synoptic hours at 00 and 12 UTC; each product contains an accumulation of data from the preceding 12-hour period.

**Cloud Analysis (CLA)**

The Cloud Analysis product estimates cloud cover and cloud top temperature in each segment. Up to three different cloud layers can be identified. For each segment, the percentage cloud cover of each layer is stored, together with the cloud top temperature. The product is generated every third hour from 0200 UTC.

**Upper Tropospheric Humidity (UTH)**

The Upper Tropospheric Humidity product contains an estimate of the mean relative humidity for an atmospheric layer between about 300 and 600 hPa. There are approximately 1800 results extracted per extraction time. The product is generated every hour.

**Clear Sky Radiances (CSR)**

The Clear Sky Radiances product contains an estimate of the mean WV channel brightness temperature from regions containing no or only low-level clouds. There are approximately 1800 results extracted per extraction time. The product is generated hourly.

**Climate Data Set (CDS)**

The CDS product contains a condensed form of the information contained in the image segments. The mean count for the extracted clusters (scenes), the standard deviation and the number of pixels for clusters, corresponding to radiation emanating from different scenes of the Earth's surface and of clouds, are given. It also includes the IR mean count of the clusters corrected for the effect of atmospheric absorption due to water vapour and aerosol. In case of high clouds that are not opaque to the IR sensor, the mean counts are also corrected for semi-transparency. The CDS product is generated on a half-hourly basis, i.e. for every image slot.

**Cloud Top Height (CTH)**

The Cloud Top Height product estimates the height of the cloud tops specified in eight vertical intervals with a resolution of 1500 m. The CTH values are extracted for image sub-areas of 3x3 IR pixels (super-pixels) which represents a horizontal resolution of 15 km at the SSP and about 22 km in southern Europe. The product is transmitted via METEOSAT in the form of a WEFAX picture and is generated for the hours at 02, 08, 14, and 20. The product is primarily used for aviation meteorology.

For more information on products extracted from Meteosat imagery, please refer to http://www.eumetsat.de.

### 3.5.2.2. India

INSAT derived Cloud Motion Vectors (CMV) are presently being disseminated on the GTS in SATOB code. CMVs are being disseminated operationally thrice a day soon after computations are made based on 3 consecutive half hourly images around 00,06 and 12hrs UTC. No other satellite derived product, Admin messages or DCP messages are disseminated using GTS or the Web site. Latest satellite pictures can be accessed on IMD's Web site http://www.imd.ernet.in/main_new.htm.

**Other Indian Products**

The India Meteorological Department also derives Outgoing Longwave Radiation (OLR), Quantitative Precipitation Estimates (QPE) and Sea Surface Temperatures (SST) from the INSAT series of satellites. SSTs and atmospheric soundings are also generated from NOAA series of US polar-orbiting satellites. NOAA products are not disseminated on GTS or Internet. Some of these products are made available on CCTs and hard copies to national users on specific requests.

### 3.5.2.3. Japan

Cloud motion vectors (SATOB: WMO international code FM 88) and typhoon information (SAREP: WMO international code FM 85) are disseminated to WMO Members via the GTS.

**Table 3.5.2.3 Dissemination of JMA Meteorological Products via GTS**

| Type of data | Description | Region of interest | Output frequency |
|---|---|---|---|
| Cloud/Water Vapour motion winds | Cloud/Water Vapour motion vectors data derived from time-sequential images | 50N-49S 90E-171W | 00,06,12,18 UTC 4 times/day |
| Typhoon analysis report (SAREP) | Location and Velocity of the typhoon centre (Special hourly observation) | For typhoons in region: Eq.-60N, 100-180E | 8 times/day (24 times/day) |
| | Estimation of the typhoon intensity | | 4 times/day |

The GMS Data Collection System (DCS) collects observation data from automated weather stations installed on ships, buoys, aircraft, isolated islands and mountains, which are called Data Collection Platforms (DCPs). Reports from DCPs are relayed through the GMS to Command Data Acquisition Station (CDAS). These reports are assembled into a bulletin form at Data Processing Centre (DPC) and transmitted to its recipient via the GTS. Data collection and distribution are automatically and regularly carried out in real time.

#### 3.5.2.4. Russia

Within the period of operation of GOMS/Electro N1 geostationary satellite (1994-1998) at 76° E, sea surface temperature products derived from GOMS data were disseminated in SATOB format via the GTS.

Data Dissemination schedules for Meteor-3, Okean-01 N7, Okean-O, Resurs-01 N3 and N4 were placed to SRC Planeta Internet server http://sputnik1.infospace.ru.

### 3.5.3. Dissemination of DCP Reports

The CGMS coordinated International Data Collection System (IDCS) is designed to relay messages from DCPs mounted on ships, aircraft, balloons and ocean buoys, i.e. they are mobile DCP likely to move across the fields of view of several geostationary meteorological satellites.

The satellite operators (or associated processing centres) compile all such DCP reports into standard WMO code messages before distribution on the GTS. These codes are described in WMO document No 306 Manual on Codes, Volume 1 (available on the WMO Web site).

Further Details and references to the IDCS can be found in Section 4.

### 3.5.4. Relay of Administrative Messages

CGMS identified the need for a system of notification to other operators and the user community whenever normal operations of a satellite were suspended. WMO agreed that for notification between satellite operators, addressed messages on the GTS could be used in accordance with the provisions of paragraph 2.4, Part II, Volume I of the Manual on the GTS. As regards the general notification of operational messages to users, the normal practice is for the satellite operators to either broadcast plain language ADMIN messages via the satellite or via web pages, and through announcements in operations bulletins, newsletters, etc.

### 3.5.5. Relay of Basic Meteorological Data

There is a requirement by the satellite operators for the relay of numerical analysis and forecast fields to support the derivation of meteorological products. Until recently the GTS was the only suitable means for transmitting this data from the main data processing centres. More recently, bilateral links, e.g. ECMWF-EUMETSAT, are regularly utilised for the transfer of numerical analysis and forecast fields.

### 3.5.6. Relay of Other Information by the GTS

#### 3.5.6.1. PRC

CMA disseminates satellite location information to its users via the GTS. The abbreviated heading is TBCI10.

#### 3.5.6.2. RUSSIA

Okean-01 N7, Okean-O and Resurs-01 N4 satellites orbital data are disseminated via the GTS in «ORBIT» code (WMO bulletin September - October 1997).

#### 3.5.6.3. USA

Using many types of satellite data, several meteorological text products are created by the Satellite Analysis Branch of the Satellite Services Division and are distributed via the GTS to a world-wide user community. Among these products are: Volcano Ash Advisories, Tropical Cyclone Position and Intensity Estimates, and Heavy Precipitation Estimates. All of these products are created in a 7 x 24 operational environment and are typically event driven with all products requiring manual intervention for their creation and distribution.

Other satellite-derived products that are created within the Satellite Services Division and are distributed via the GTS include: High Density Winds, and ASOS Cloud Products. Both of these products are created automatically and are only quality controlled by personnel after their production for completeness and accuracy.

**Volcanic Ash Advisories**

The Washington Volcano Ash Advisory Centre (VAAC) was established on November 1, 1997 under the International Airways Volcano Watch, coordinated by the International Civil Aviation Organisation (ICAO) to help warn aircraft of the major hazards associated with volcanic ash. GOES-8 and GOES-10 data (bands 1, 2, 4, and 5) are used, either alone or in multi-spectral techniques, to help detect volcanic ash. Upon the identification or receipt of notification of the presence of volcanic ash within the VAAC's area of responsibility, a Volcano Ash Advisory (VAA) is created and disseminated via the GTS. These messages are updated every 6 hours, or as required, and include information as to the vertical extent, areal extent, onset and duration of volcanic eruptions. Included with these messages are graphical analyses of detectable ash clouds and are provided on the Internet only.

The WMO headers for the VAAs as distributed over the GTS are: FVXX20KWBC, FVXX21KWBC, FVXX22KWBC, FVXX23KWBC, FVXX24KWBC, FVXX25KWBC, FVXX26KWBC, and FVXX27KWBC.

The home page of the Washington VAAC, which contains current VAAs, can be viewed at: http://www.ssd.noaa.gov/VAAC/washington.html.

More information about the Volcano program of the Washington VAAC can be viewed at: http://www.ssd.noaa.gov/VAAC/program.html.

A scientific paper describing the activities of the Washington VAAC can be viewed at: http://www.ssd.noaa.gov/VAAC/PUB/carsam.html.

**Tropical Cyclone Position and Intensity Estimates**

GOES satellite imager data (channels 1, 2, and 4) are used to classify tropical systems, every 6 hours, using the internationally recognised Dvorak technique. GMS-5 and Meteosat-6, and Meteosat-7 satellite data are used in areas outside of the GOES footprint. Satellite weather bulletins are created by the Satellite Analysis Branch and distributed via the GTS to foreign countries when tropical disturbances are in the Indian Ocean, the Northwest Pacific Ocean west of 180°E and the South Pacific Ocean. A tropical disturbance must have a current intensity (CI) of T2.0 or greater (30 knots) to warrant sending a message to a foreign nation. The WMO headers are as follows:

| | |
|---|---|
| WWPN20KWBC | Northwest Pacific Ocean west of 180°E to 100°E |
| WWOS20KWBC | Southwest Pacific Ocean east of 135°E |
| WWIO20KWBC | North Indian Ocean west of 100°E |
| WWIO21KWBC | South Indian Ocean west of 135°E |

These storm bulletins are disseminated every 6 hours using the data times of approximately: 0230 UTC, 0830 UTC, 1430 UTC, and 2030 UTC.

In addition to these storm bulletins for tropical cyclones, twice a day the Satellite Analysis Branch creates and disseminates a weather summary for the Indian Ocean west of 100°E, generally between 20°N and 20°S. These bulletins contain information of all classified tropical cyclones within this area and a description of all other significant tropical weather. These bulletins are created using day (0830 UTC) and night (2030 UTC) satellite imagery from GMS-5, Meteosat-6, and Meteosat-7 and issued under the following WMO headers:

| | | |
|---|---|---|
| TCIO10 VIS/IRDAY | Indian Ocean west of 100°E | using 0830Z satellite data |
| TCIO11 IRNITE | Indian Ocean west of 100°E | using 2030Z satellite data |

All tropical products created and disseminated by the Satellite Analysis Branch can also be found at: http://www.ssd.noaa.gov/SSD/ML/realtime.html#TROPICAL.

At this Web site, there is also information regarding the Dvorak technique.

**Heavy Precipitation Estimates**

The Satellite Analysis Branch uses the Interactive Flash Flood Analyser (IFFA) to estimate convective rainfall amounts. The IFFA is a manual technique that produces satellite rainfall estimates by analysing the changes of cloud top temperature in two consecutive (half-hourly) GOES-8 or GOES-10 infrared images. Visible satellite data are used as well to help further identify features likely to produce heavy rainfall. These satellite derived rainfall estimates are created for the lower 48 states and over Puerto Rico whenever heavy rains are threatening to produce, or are already producing flash flooding. These estimates are disseminated via the GTS to the National Weather Service Field Office and onto AWIPS under the WMO header: TXUS20KWBC.

In addition to providing the estimated amount of rainfall, the messages also contain information on trends as seen in satellite imagery and short-range (nowcasting) information. The purpose of these messages is to provide heavy rainfall guidance to the NWS for issuance of flash flood warnings, watches, and advisories. Messages can be sent as frequently as every half-hour, approximately 20 minutes after the latest satellite image. An associated graphical product is typically produced with each text product and is placed on the Internet.

The heavy precipitation estimate messages and graphics can be found at: http://www.ssd.noaa.gov/SSD/ML/pcpn-ndx.html.

More information on the precipitation team of the Satellite Analysis Branch can be found at: http://www.ssd.noaa.gov/SSD/ML/pcpn-team.html.

**High Density Winds**

Other satellite-derived products that are created within the Satellite Services Division and are distributed via the GTS include High Density Winds. Since 1992 the production of the cloud motion vectors in NESDIS has been fully automated. In 1998 the cloud motion vector package was upgraded to provide high quality imager-based cloud drift (IR) and water vapour motion winds at significantly increased spatial and temporal resolution every three hours for the Northern and Southern hemispheres. Other advances included new automated registration quality control, ensuring properly registered images are used to produce satellite wind vectors, and new quality control strategies employed for the satellite derived winds which encourages "buddy-checking" of different wind product types while retaining satellite-derived wind vectors in areas of high cyclonic or anticyclonic curvature. All cloud motion vector products are distributed automatically and are only quality controlled by personnel after their production for completeness and accuracy only. Following is a table of the SATOB headers for wind products available on the GTS.

**Table 3.5.6.3 SATOB headers for wind products available on the GTS**

| **Product** | **Goes East** | **Goes West** |
|---|---|---|
| Cloud Drift (IR) | TW[NS]A01 | TW[NS]A03 |
| Water Vapour | TW[NS]A04 | TW[NS]A06 |
| Visible | TW[NS]A07 | TW[NS]A09 |
| Picture Triplet | TW[NS]11 | TW[NS]A13 |

For more information on high-density winds production in NESDIS including accuracy statistics please visit the following web sites:

http://orbit-net.nesdis.noaa.gov/goes/winds/html/windinfo.html, http://www.ssd.noaa.gov/.

**ASOS Cloud Product**

The Automated Surface Observing System (ASOS) is a key component of the modernisation program in the National Weather Service (NWS). Among the automated sensors in this sophisticated instrument package is a ceilometer, which can delineate clouds up to 12,000 feet. Using radiances measured from the GOES-8/M sounding instrument, a technique for calculating cloud top pressure is used to augment the ASOS cloud observation above 12,000 feet. From these GOES radiance calculations, images are created to show cloud top pressure over the United States. For each cloudy field of view, the CO2 Absorption Method is used to calculate the pressure of the cloud top and the effective cloud amount. Currently, the processing algorithm for GOES-8/M utilises measurements in the 15 micron CO2 absorption band (channels 2, 3, 4, and 5) for cloud height calculation and two long wave (11-12 micron) window channels (7 and 8) for surface skin temperature determination. With the GOES sounders now operational instruments, data are routinely received over the US, and a new image can be created every sixty minutes.

In order to visually enhance the range of cloud top pressures, the images are colour-coded according to cloud top pressure. In each image, the grey-shaded areas depict clear regions. The colour levels define pressure (in hPa) ranging from orange at the lower heights (higher pressures), to blues and white at the higher heights (lower pressures). There are limitations in the coverage due to the location of the GOES satellites (over the equator and typically at either 90 or 135 degrees West longitude) and the curvature of the Earth, rending data beyond 62.5 degrees viewing angle to be of reduced quality. Thus, the "step effect" observed in the extreme northeast and northwest portions of the image is the effective limit of this product. The GOES derived cloud top pressure is a very useful product for aviation, as well as aiding the initialisation of numerical models.

From the early days of GOES-8, a historical sample loop of four cloud top pressure images (0046UTC, 0846UTC, 1246UTC, and 1946UTC) is shown for 28 November 1994. Nowadays, hourly composites of the cloud top pressure images derived from the Sounders on both GOES satellites (-East and -West) are available in near real-time. Please refer questions to Tony Schreiner / Tony.Schreiner@ssec.wisc.edu.

**GTS distributed Soundings Products**

The NOAA Polar Satellite data is distributed on the GTS in the traditional alphanumeric codes as SATEM and SARAD code and in the newer BUFR format. The BUFR data is a more complete product than the SATEM-SARAD combination both in number of observations and in the number of parameters provided with each observation.

Both of these products are derived from the sounding product files for the NOAA-14 and NOAA-15 satellites. The SATEM - SARAD product has been sampled from the full resolution product to a product of approximately 500km spacing. The BUFR product is at 120km spacing. The actual derived retrievals were not averaged, but were sampled to get the proper spacing.

Information about the operational processing of the soundings data, graphics of the data and statistics about the processing can be found at:
http://psbsgi1.nesdis.noaa.gov:8080/PSB/SOUNDINGS/index.html.

This is the web page for the operational side of the soundings processing. It links to the development side of the soundings processing for the graphics of the data and some discussion about the systems.

Ellen Brown (ebrown@nesdis.noaa.gov) and Vince Tabor (vtabor@nesdis.noaa.gov) are available to answer any questions about polar satellite soundings processing.

## 3.6. DATA POLICY OF CGMS MEMBERS

### 3.6.1. EUMETSAT

EUMETSAT data is provided free of charge to National Meteorological Services of its Member States and Cooperating States for their official duty use.

Official duty use covers all activities taking place within the organisation of NMSs and external activities of a NMS resulting from legal governmental or intergovernmental requirements relating to defence, civil and safety of life and property.

A set of data, products and services is available on free and unrestricted basis as “essential “ data and products in accordance with WMO Resolution 40. A further set of data and products is made available to NMSs of non-Member States without charge for their official duty use.

All other users may receive sets of data, products and services under conditions defined by the EUMETSAT Council. In some cases this means that they will have to acquire a licence as an end-user or a service provider for three-hourly, hourly or half-hourly HRI data against payment of a fee.

Research projects and educational users are granted access without charge to three-hourly, hourly or half-hourly HRI data. This also applies to NMS of non-Member States subject to tropical cyclones. Furthermore access without charge is also provided to support monitoring of disasters or emergencies and in accordance with relevant UN resolutions.

Additionally, NMSs of countries with a GNP per capita below or equal to 2,000 US$ are granted free access to hourly and half-hourly HRI data.

EUMETSAT has bilateral arrangements that include real-time data exchange with:

- NOAA for GOES-East and GOES-West images
- ROSHYDROMET for GOMS images
- JMA for GMS
- ISRO for INSAT images

All this data is disseminated from Meteosat.

In the framework of the Initial Joint Polar System, the joint polar satellite system with NOAA, it is foreseen to receive data from NOAA-N and NOAA-N’, as well as SSMI data from the DMSP satellites.

### 3.6.2. India

Processed INSAT Data can be made available to the other Satellite operators on bilateral basis after signing of specific MOU in accordance with normal procedures. Data is also supplied on payment basis with a certificate from the user that data will only be used for the purpose for which it has been supplied. Further, the MDD data can be accessed in real-time by neighbouring countries, which lie within the footprint of the transmit antenna. For this purpose, dialogue is first initiated at appropriate higher levels with Indian Government.

### 3.6.3. Japan

JMA provides two types of services to users worldwide: the direct broadcast service and the GTS service. GMS takes 28 full disk images a day and directly disseminates them through the spacecraft. Various meteorological parameters are extracted and some of them are distributed through GTS. As direct broadcast services, cloud image data obtained by GMS are utilised by 26 countries/ territories in the western Pacific area: Australia, Southeastern Asian countries/territories etc.

GMS cloud image data are opened to all users. JMA requests a user to indicate a phrase that “the cloud imagery was originally obtained from GMS of JMA”, when the user utilises (publish, provide or re-distribute) GMS imagery. But JMA does not request royalties for any utilisation of GMS imagery. JMA also requests a user who is going to re-distribute GMS imagery by telecommunications media to apply for permission of the distribution to JMA.

Meteorological parameters such as cloud motion winds extracted from GMS cloud image data are distributed as weather reports through the GTS to meteorological services world-wide. SAREP, which is described of determined central position of a typhoon and estimated intensity of the typhoon from GMS images, is to be distributed to meteorological services in Southeastern Asia through GTS.

### 3.6.4. PRC

S-VISSR and WEFAX of FY-2 A/B and CHRPT of FY-1 C/D are freely disseminated to users worldwide at no cost.

### 3.6.5. Russia

The Data policy of Roshydromet, as an operator of Russian meteorological and oceanographic satellite missions, corresponds to WMO requirements allowing users free direct data readout as well as free access to any operational meteorological data disseminated via the Internet and GTS.

### 3.6.6. USA

The guiding principle for most U.S. Government data policy is that government information is a valuable national resource, and its economic benefits are maximised when it is available in a timely and equitable manner to all. While there are exceptions, open and unrestricted access is the typical model for disseminating U.S. Government information. The U.S. Office of Management and Budget (OMB) Circular A-130 advises agencies to avoid restrictions of or regulations on the use, resale or re-dissemination of federal information products by the public. The Paperwork Reduction Act of 1995, PL 104-13, Section 3606(d), codifies the information dissemination provisions of OMB Circular A-130.

Standard pricing guidelines support the open and unrestricted access model. Per OMB Circular A-130, user charges should be set at a level no higher than that, which would recover the cost of data dissemination. Original collection or processing costs are not to be included.

There are exceptions to both dissemination and pricing standards. The U.S. recognises there are possible conflicting interests with free and open access to information, and has restricted access under certain circumstances. Aside from national security considerations, the U.S. recognises that in the interests of providing validated data, some period of exclusive use may be necessary. The U.S. seeks to keep such periods of exclusive use to a minimum.

In the context of international agreements, the U.S. recognises that other countries may have different policies regarding data use and dissemination. In data sharing agreements with other countries, the U.S. has respected the rights of those countries to control the dissemination of data generated by their systems and/or their instruments. However, wherever possible and in conformance with U.S. Government policy, NOAA/NESDIS seeks to promote the widest possible availability of Earth observation data, especially for the protection of life and property and the furtherance of essential scientific inquiry.

U.S. Government agencies have partnered with private operators through various mechanisms. These mechanisms have included data purchase contracts, agreements for the placement of U.S. Government instruments on commercial platforms, and U.S. Government funding for a privately owned system which provides a subset of its data back to the U.S. Government.

The policies described above allow for a measure of U.S. Government flexibility in partnerships with foreign programs and with the private sector. Their common requirement is the unencumbered ability of the U.S. Government to utilise data from these systems to support its own environmental forecasting, environmental monitoring, and global change research responsibilities, and with the broadest possible user community.

### 3.6.7. WMO

The Twelfth World Meteorological Congress, in Geneva in June 1995, adopted a policy on, and a new practice for, the international exchange of meteorological data and products that stressed that WMO was committed to broadening and enhancing the free and unrestricted international exchange of meteorological and related data and products. The new practice states that:

- Members shall provide on a free and unrestricted basis essential data and products which are necessary for the provision of services in support of the protection of life and property and the well-being of all nations, particularly those basic data and products required to describe and forecast weather and climate, and to support WMO programmes;

- Members should also provide the additional data and products required to sustain WMO programmes at the global, regional and national levels and, as agreed, to assist other Members in the provision of meteorological services in their countries. At the same time, it is understood that Members may be justified in placing conditions on the re-export of such data and products for commercial purposes outside the receiving country or group of countries forming a single economic group, for reasons relating to national legislation or costs of production;

- Members should provide to the research and education communities, for their non-commercial activities, free and unrestricted access to all data and products exchanged under the auspices of WMO, with the understanding that their commercial activities are subject to the same conditions as above.

Congress stressed that all meteorological and related data and products required to fulfil Members' obligations under WMO programmes would be encompassed by the combination of essential and additional data and products exchanged by Members.

## 4. THE INTERNATIONAL DATA COLLECTION SYSTEM (IDCS)

The purpose of the International Data Collection System (IDCS) is to allow the re-distribution of meteorological information measured by mobile and often remote Data Collection Platforms (DCP) using the geostationary meteorological satellites to relay the DCP messages. Collected data are acquired and processed by the central satellite ground facilities and then distributed to the different users in various ways. From a functional point of view, DCP tend to be mainly self-timed (i.e. they transmit their reports automatically within pre-set times and frequency slots, the whole process being controlled by a stable internal clock. DCP operating within the IDCS are normally mobile, i.e. they might be sea-based (buoys, ships) or airborne (aircraft, balloons). Exceptionally, and only with the agreement of CGMS, certain land based DCP forming part of internationally recognised (e.g. WMO) networks, can make use of the IDCS.

CGMS has agreed a common standard for the IDCS, enabling every DCP in the system to operate with any of the geostationary meteorological satellite systems. Particular emphasis is placed upon the technical characteristics of the international DCP, system operational procedures and administrative aspects.

Full details of the IDCS can be found in the CGMS Document IDCS Users Guide (currently Issue 8, dated 1998). The document provides specifications and guidelines for the design of international DCP, describes procedures for their admission to the system (currently, jointly administered by EUMETSAT, Japan and USA) and details the operational support services provided by the satellite operators to DCP operators. Hard copies of this document can be obtained from the CGMS Secretariat (EUMETSAT) and the document (reference CGMS02) as a PDF file format can be viewed and downloaded from the CGMS publications area of the EUMETSAT Web site http://www.eumetsat.de.

# 5. TELECOMUNICATIONS

The discussion of radio frequency topics by CGMS has continued since the very beginning. Issues regularly discussed include the sharing of frequency bands by different satellite operators, interference to existing frequencies from non-authorised sources, protection of frequencies planned for use by future satellites and their instruments, the submission of topics of concern to CGMS to the meetings of the Space Frequency Coordinating Group and World Radio Conference, and the discussion of reports from these meetings. The range of topics became so large that in 1990 CGMS decided to create a Telecommunications Working Group (WG I) which has subsequently met during each meeting of CGMS and reported to the Plenary on the last day of business. Many of the topics on the Agenda have been discussed and agreed over a period of several years. As a consequence a general historical summary follows with the significant points of interest resulting from the most recent meeting of the Working Group described in section 5.3

## 5.1. Coordination of Frequency Allocations

Frequency management issues are regularly discussed during CGMS meetings. Co-ordinated approaches of CGMS members are agreed and submitted to the national frequency authorities of the individual members for approval. In addition, CGMS Member organisations are actively involved in the ITU processes related to frequency allocations. This is especially the case in the areas of "Meteorological-Satellite Service", "Earth Exploration-Satellite Service" and "Meteorological Aids Service".

CGMS experts participate in various meetings of the ITU including Conference Preparatory Meetings and World Radio Conferences.

In the field of Meteorological-Satellite Service, the attempts of Mobile-Satellite Service (MSS)to share the 1675-1683 MHz and 1690-1710 MHz bands on a co-primary basis have been discussed since 1992, concluding in 2000 that sharing is not feasible. Recently completed studies concluded that sharing in the 1683-1690 MHz band is not feasible as well in most of the world due to the large number of GVAR and SVISSR ground receivers However, MSS sharing with the few geostationary metsat main Earth stations operating in 1670-1675 MHz is possible if proper protection is provided by the MSS. The 2003 ITU World Radiocommunication Conference approved a worldwide MSS allocation in 1670-1675 MHz, with the necessary protection to permit continued interference-free operations of the metsat main Earth stations. Since CGMS XII, a close collaboration between CGMS and the Space Frequency Coordination Group (SFCG) has been established. CGMS has requested that the Secretariat maintain regular contacts with the SFCG in order to be advised of relevant frequency allocations. CGMS and SFCG are represented in each other's meetings as observers and a report of the most recent SFCG meeting is presented to each meeting of CGMS.

## 5.2. INTERFERENCE TO SATELLITE TRANSMISSIONS AND TO THE IDCS

### 5.2.1. Interference in the Meteosat DCP Report Up-Link Frequency Band

Interference in the Meteosat DCP report up-link frequency band was first reported by ESA in 1980, and since by EUMETSAT. The band is frequently disturbed by an interfering signal that has a very high stability (1 x 10 E-9) and a repetition rate of almost exactly 10 Hz. Over the years, CGMS Members and WMO have co-ordinated several attempts to inform the ITU about this interference and possible sources of the signals. Up to now no satisfactory solution to the problem has been found. The interference (most likely from a military source) actually disturbs Data Collection Systems operated by most CGMS Members and leads to periodic data loss on several DCP channels.

### 5.2.2. Scintillation Effect

In February 1978, Japan reported a signal loss of 10-12 dB for several hours on the GMS S-band link. This decrease in signal level coincided with similar effects on VHF and C-band links of other satellites. A probable cause was the scintillation effect in the ionosphere. ESA also reported a similar, but not identical, problem in February 1978, but on a different date. The USA had reported significant signal attenuation of S-band communications from its polar-orbiting satellites received at Gilmore Creek. These effects were ascribed to aurora events.

At CGMS X, Japan reported the results of their investigations into ionospheric scintillation. Their study highlighted the seasonal and time dependency of the frequency of occurrence of the scintillation effect. The occurrence was more frequent in the summer and a peak in activity appeared around midnight. The scintillation was thought to have been caused by F-layer variability. At CGMS XII, Japan stated that the margin on the communications link between its spacecraft and the CDAS was so large that operations could be maintained with little degradation from scintillation. However, users who operated stations with 3 to 4 dB margin were more likely to be affected. Japan agreed to continue the investigation, especially with the cooperation of users in various regions as the occurrence and magnitude of scintillation could vary with both ground station location and antenna orientation.

To date, no correlation of signal loss with scintillation had been observed with the other geostationary meteorological satellites.

### 5.2.3. Impact of Solar Noise

EUMETSAT, Japan and USA have all reported the effects of solar noise when the sun, the spacecraft and the ground stations are aligned (co-linear). Whilst Japan briefly suspends its operations during the period of noise, EUMETSAT and USA do not suspend the operations, but continue with degraded quality for the few affected images.

## 5.3. SUMMARY OF DISCUSSIONS FROM THE MOST RECENT MEETING OF THE WORKING GROUP ON TELECOMMUNICATIONS

### 5.3.1. WRC and Coordination of Frequency Allocations

#### 5.3.1.1. Results of the World Radio Conference 2003

The World Radio Conference 2003 (WRC-2003) took place in Geneva from 9th June to 4th July 2003. More than 2300 delegates attended the Conference, representing about 150 national administrations and several so-called Sector Members. The issues of interest to CGMS can be broadly split into the following areas, Meteorological Satellite Service, Earth Observation, Space Science. Other issues of interest were satellite telecommunication and satellite radio-navigation.

♦ **Meteorological Satellite Service**

There were two agenda items involving the Meteorological Satellite Service. The results were as follows:

– **Non-GSO MSS service links in bands below 1 GHz**

*"to consider additional allocations on a world-wide basis for the non-GSO MSS with service links operating below 1 GHz, in accordance with Resolution **214 (Rev.WRC-2000)**"*

This issue was on WRC agendas since 1992. The MSS seeks spectrum below 1 GHz for so-called "Little LEOs", i.e. low earth orbiting satellites performing mobile services such as paging, data collection etc. Several candidate bands have been identified including parts of the band 401 – 406 MHz. This band is used for radiosonde operations (MetAids) and part of the band for Data Collection Systems of meteorological satellites (LEO and GEO). WMO has conducted studies on the future requirements for the band and has submitted documents to ITU and WRC. A dedicated resolution pointing to the band 401 – 406 MHz was deleted during WRC-2000. In discussions in the ITU as well as CEPT there has been no support for new MSS allocations. For the band 401 – 406 MHz there has been strong opposition to the MSS request.

**Outcome of WRC 2003:** No new MSS allocations were made and Resolution 214 on this issue was finally suppressed. This issue will not be allowed for future WRC agendas any more. The MetSat allocations in the band 401 – 403 MHz are therefore safe.

– **MSS in the 1-3 GHz band**

*"to consider the additional allocations to the mobile-satellite service in the 1-3 GHz band, in accordance with Resolutions **226 (WRC-2000)** and **227 (WRC-2000)**"*

This agenda item targeted specifically the bands 1518 – 1525 MHz (downlink) and 1683 – 1690 MHz (uplink), but was open to examining other frequency bands between 1 and 3 GHz.

The band 1675 – 1700 MHz is allocated to both the Met-Aids and Met-Sat services with the Met-Sat allocation extending up to 1710 MHz, and is vital to the operations of the WMO as well as other meteorological services in many administrations. The band is essential for many CGMS satellite programmes.

Studies in the ITU-R, including several submissions by EUMETSAT, have shown that MSS (Earth-to-space) cannot share with the Met-Sat or Met-Aids services without undue constraints. For example, three independent studies have shown that sharing between the MSS and MetSat in the 1683-1690 MHz band would be very difficult due to the hundreds of GVAR/S-VISSR stations, including a number of mobile GVAR earth stations. Earlier studies have proven that sharing is not feasible in the bands 1690 – 1698 MHz due to thousands of user stations for geostationary meteorological satellite systems as well as 1698 – 1710 MHz due to downlinks of polar orbiting meteorological satellites to user terminals and main Earth stations. Therefore, any MSS allocation in the 1675-1710 MHz band was considered practically unusable and consequently opposed.

**Outcome of WRC-03:** A primary allocation to the MSS was made in the band 1668 – 1675 MHz for all ITU regions. Footnotes to protect existing services were added to the allocation. This outcome of the WRC 2003 was the desired one and is totally acceptable to the meteorological community in view of the very limited use of this band and the protection afforded to existing meteorological stations. On a global scale, the band 1670 – 1675 MHz is only used by very few data downlinks, which can be protected.

Existing MSS allocations in region 2 within the band 1675 – 1700 MHz were deleted. Resolution 227 was also deleted which implies that this issue will not be included on future WRC agendas. The new allocation and the consequent deletion of other allocations terminate now an ongoing activity from MSS to obtain additional spectrum. This activity was on all agendas of WRCs since 1992.

♦ **Earth Observation**

Several items were of interest for Earth Observation (EESS in ITU terminology):

- Elimination of some legal uncertainty on the use of the 35.5-36 GHz band by rain radars
- Definition of regulatory limits for unwanted emissions into bands reserved for EESS passive sensors only
- Protection from proposed allocations to mobile satellite systems in various bands used by meteorological satellites.

♦ **New allocation in the 432-438 MHz for P-band SAR applications**

*"to consider provision of up to 6 MHz of frequency spectrum to the Earth exploration-satellite service (active) in the frequency band 420-470 MHz, in accordance with Resolution 727 **(Rev.WRC-2000)**"*

This long-standing issue, already discussed unsuccessfully at WRC-97, has finally been positively resolved with a 6 MHz secondary allocation at this Conference. The operational limitations to be applied to the SARs operating in this band (ITU-R Recommendation SA.1260-1) will still allow them to cover forest biomass and Antarctic ice measurements, the two main observation targets identified for this type of instrument, with a spatial resolution of 100 meters.

This result has been possible on the basis of an agreement that all future operators of these satellites will publish, in advance, on the Space Frequency Coordination Group (SFCG) web site the observation areas and schedule of their campaigns, so that the other users of the band can be aware of the planned use beforehand.

- **Issues related to HAPS**

*"to consider regulatory provisions and possible identification of existing frequency allocations for services which may be used by high altitude platform stations, taking into account No. **S5.543A** and the results of the ITU-R studies conducted in accordance with Resolutions **122** and **734** **(WRC-2000)**"*

This agenda item is of interest to CGMS Members in order to protect the sensor band 31.3 – 31.5 GHz (used by AMSU on METOP and NOAA satellites) from unwanted emissions by High Altitude Platform Systems (HAPS) in the adjacent band.

**Outcome of WRC 2003:** Very stringent limits on the unwanted (out-of-band and spurious) emissions (-100dBW/m²) by HAPS uplink stations have been put in the ITU Radio Regulations. This will guarantee the protection of the "window" for the meteorological vertical sounders and at the same time will allow the development of HAPS systems around 31 GHz in a number of interested countries, mainly in Asia, but including also Russia. This regulation represents also the very important first case of having a hard limit specified for unwanted emission levels in the Radio Regulations; this should open the door for similar protection levels needed for other bands used for satellite passive sensing.

- **Non-GSO MSS feeder links in bands around 1.4 GHz**

*"to consider allocations on a world-wide basis for feeder links in bands around 1.4 GHz to the non-GSO MSS with service links operating below 1 GHz, taking into account the results of ITU-R studies conducted in response to Resolution 127 (Rev.WRC-2000), provided that due recognition is given to the passive services, taking into account No. 5.340"*

(This item deals with the protection of the 1.4 GHz band (to be used by SMOS) from unwanted emissions by new Mobile Satellite feeder links in nearby bands)

US industry has made a strong attempt to get an allocation for MSS feeder link despite the unfavourable conclusions of compatibility studies conducted by the relevant ITU-R Working Parties and the incompleteness of these studies. The CEPT submitted an ECP for no allocations to MSS feeder links to WRC-03 which was signed by 35 European administrations. Moreover, around 60 other administrations submitted proposals for no allocations to MSS feeder links. Despite this very strong position expressed by almost 100 countries, the USA, supported only by 3 other administrations, pushed its desire for an allocation by using all available means.

**Outcome of WRC 2003**: After lengthy and heavy debate, it was finally possible to limit the allocation for MSS to a secondary status restricted to the bands 1390-1392 MHz for uplinks and 1430-1432 MHz for downlinks.

Furthermore, and very important, the allocations are only provisional and tied to a Resolution which does not allow the use of these bands for MSS feeder links before completion of all ITU-R studies to be reviewed by WRC-07.

- **Use of the frequency range 5 150-5 725 MHz**

ITU Resolution 736 (WRC-2000) requests

*"to consider, in accordance with Resolution **736 (WRC-2000)**, regulatory provisions and spectrum requirements for new and additional allocations to the mobile, fixed, Earth exploration-satellite and space research services, and to review the status of the radiolocation service in the frequency range 5 150-5 725 MHz, with a view to upgrading it, taking into account the results of ITU-R studies"*

Protection of the EESS active sensors operating in the band 5250-5350 MHz (e.g. SAR on ERS-1 and Envisat) from new wireless LANs (RLAN) to be deployed in this band

This was one of the most difficult issues at WRC-03. The ITU studies conducted on this issue in preparation of WRC-03 had concluded that a proper protection of the EESS active sensors could only be achieved by limiting the RLAN to indoor use only and by imposing some additional technical constraints. This conclusion was supported by the European RLAN industry, which confirmed that these constraints were acceptable to them. Compatible European regulations in this area have been put in place already since 3 years. Unfortunately the US and Canadian national regulations allowed outdoor usage of this equipment as well as higher power and therefore these Administrations, supported by North American industry, objected to the results of the ITU studies. While the Canadian problem has been solved with a compromise that will allow limited outdoor usage only with antennas with strong attenuation above the horizontal plane, it has been very difficult to deal with the US objections.

**Outcome of WRC 2003**: The solution has been to introduce regulatory text that invites Administrations to encourage "predominantly indoor" systems, but at the same time allows Administrations to use alternative methods to protect the EESS systems. What these alternative methods may be is unclear, since all the technically meaningful methods have been analysed. A new footnote has been introduced in the Radio Regulation for this band, stating that no harmful interference shall be generated by the RLAN devices towards the EESS sensors. This implies that demonstrated interference shall lead to the obligation of switching off the RLANs.

- **Extension of the size of the allocation to EESS active sensors in the 5 GHz range from the current 210 MHz bandwidth to 320 MHz, to allow future high-resolution altimeters or SARs in C-band (eventual JASON-2 follow on).**

**Outcome of WRC 2003:** The extension of the band allocated from 5250-5460 MHz to 5250-5570 MHz has been achieved at this WRC. The allocation has been given in the same band also to Space Research active systems (to be used for planetary exploration).

♦ **Unwanted emissions**

*"to consider issues related to unwanted emissions:"*

(This agenda item dealt with unwanted emissions from adjacent bands into passive sensor bands. Several bands were identified were regulations are required to protect passive sensors. Active services were very reluctant to establish mechanisms for such protection and there was no conclusive output from 2003. The agenda point was put on the agenda of WRC 2003.)

One of the problems discussed was related to the protection of the band 50.2-50.4 GHz (used by AMSU on METOP) from unwanted emissions by High Density Fixed Satellite Systems (HDFSS) operating uplinks in the lower adjacent band. It has been possible to insert in the associated Resolution some text inviting Administrations to limit HDFSS uplink deployments in the frequencies next to 50.2 GHz until proper ITU studies will have identified mechanisms to protect the sensors in the 50.2-50.4 GHz band. Although the threat is not imminent (some even question if these high frequency bands are really suitable for HDFSS applications), studies are needed in this area in the future.

**Outcome of WRC 2003:** Despite strong resistance by some important Administrations, the WRC decided that the problem of unwanted emissions into passive bands will have to be studied and technical regulations should be put in place. This will constitute one of the most complex issues to be covered in the next ITU study cycle.

♦ **Space Science**

The following WRC-03 agenda items are of interest to Space Research and the following results were achieved:

- Primary allocation to Space Research at 26 GHz for wideband data downlink.
- Simplified coordination procedures for telecommand links around 7 GHz.
- Elimination of an allocation to Inter-satellite Service in a band around 32 GHz used for deep-space satellites data downlink.
- Confirmation of the Space Research data downlink allocation near 38 GHz.
- Extension of the C-band allocation for Space Research active sensors.

♦ **Agenda for WRC-07**

As usual the agenda for WRC-07 contains quite a mix of different subjects. 21 Agenda Items have been included. Several agenda items proposed by EUMETSAT were agreed and will be on the agenda of the next WRC, namely,

- **expansion of MetSat Allocation**

EUMETSAT has forwarded via CEPT the request to include a new agenda item concerning the expansion of the present footnote allocation for the Meteorological Satellite Service in the band 18.1-18.3 GHz by 100 MHz.

The new allocation either in the band 18.1 – 18.4 GHz or 18.0 – 18.3 GHz should be on a primary status and could be used for geostationary meteorological satellite downlinks (for example P-MSG). The agenda item was accepted and was put on the agenda for WRC 2007. It was combined with other EESS activities as follows:

An agenda item related to sharing studies in the bands 10.6-10.68 GHz and 36-37 GHz between passive EESS sensors and terrestrial services, as well as to the extension by 100 MHz of the current Meteorological Satellite downlink band 18.1-18.3 GHz (to cover the higher data rates required by the third generation of Geostationary Meteorological Satellites).

– **Consideration of the use of frequencies between 275 and 3000 GHz**

It is necessary to provide suitable frequency allocations for passive sensor atmospheric measurements in the EESS (passive) and SRS (passive). There are already spaceborne passive sensors utilising frequency bands above 275 GHz. Planned and existing instruments include MLS (USA), SMILES (Japan) as well as other sensors which use spectra above 275GHz.

Protection is presently only given by footnote S.5.565 that was revised by WRC-2000. This footnote is quoting that the band 275 – 1000 GHz may be used for experimentation and development of various active and passive services. A list of frequencies is contained in the footnote but this list is not complete. Operations of sensors in such frequency bands are not adequately protected. It is therefore necessary to open the table of frequencies to include frequencies up to 1000 GHz.

An agenda item was put on WRC 2010 to consider the expansion of the table of frequencies up to 3000 GHz. A corresponding resolution was adopted.

♦ **Other agenda items of interest to CGMS for future WRCs:**

- the extension by 200 MHz of the EESS active sensors allocation in the band 9.5-9.8 GHz, to cover the sub-meter resolution required by sensors like the SAR on COSMO-SKYMED.
- IMT-2000 systems and beyond.
- the continuation of studies in the bands identified for HAPS
- the continuation of studies on compatibility between MSS feeder links and passive services around 1.4 GHz (SMOS)
- the identification of global harmonised frequencies for the use of Internet applications
- studies and regulatory measures to protect EESS passive sensors from unwanted emissions

- studies and regulatory measures to protect radioastronomy sites from unwanted emissions of space services
- Studies regarding devices using Ultra-wideband Technology.

♦ **Summary**

The results of WRC 2003 were generally very good for CGMS Members. The main positive results were:

- The termination of activities to allocate spectrum to MSS in bands presently used by Meteorological Satellite Service. The only allocation MSS achieved (1668 – 1675 MHz) is in a band not used by EUMETSAT.
- The inclusion of hard limits on HAPS operations neighbouring to the band 31.3 – 31.8 GHz. This was based on results of EUMETSAT studies successfully forwarded through ITU working parties and study groups.
- The expansion of EESS (active) allocation from 210 MHz to 320 MHz bandwidth for altimeters in the band 5250 – 5570 MHz.
- The inclusion of a new agenda item related to the expansion of the Meteorological Satellite Service footnote allocation in the band 18.1-18.3 GHz by 100 MHz to the WRC 2007 agenda.
- The inclusion of the opening of the table of frequencies from 275 GHz to 3000 GHz as an agenda item to WRC 2010.

### 5.3.2. 21st Space Frequency Coordination Group (SFCG) Report

The report of the SFCG meeting was submitted for information (CGMS XXX-USA-WP-20). Up-to-date information on SFCG activities can be obtained via the SFCG website: http://www.sfcgonline.org.

### 5.3.3. Introduction of Car Radar Devices (CRD) operating in the frequency band 21–27 GHz

CGMS XXX-EUM-WP-12 stated a group of car manufacturers had organised themselves under the name SARA (Short-Range Automotive Radar) and have recently published plans to introduce Short-Range Radar (SRR) equipment on cars using Ultra Wide Band (UWB) technology.

The target frequency range for this application is 22.625–25.625 GHz, which includes the band used for very important measurements from passive sensors at 23.6 – 24 GHz. This band is a unique natural resource allowing the correction of "windows" between 1– 40 GHz from the water vapour attenuation bands, and giving the necessary correction for using the 50–60 GHz band for vertical temperature profiling. Due to the importance of this band for passive sensor measurements, the band is protected in the ITU Radio Regulations by FN 5.340 stating "No emissions allowed in this band".

The SARA group has started activities to achieve licenses for their equipment. Several workshops have been conducted under the responsibility of the European Radiocommunication Office (ERO) and European frequency regulatory administrations involving SARA and representatives of so-called "victim services" including the EESS.

The discussion process in Europe has resulted in a situation where a draft standard for SRR devices proposed by the European Telecommunications Standards Institute (ETSI) has been put on hold until compatibility between the new service and the existing protected services in the band has been proofed. Centre National d'Etudes Spatiales (CNES), ESA, and EUMETSAT have submitted compatibility studies. These studies were based on actual ITU Recommendations and input parameters received from SARA as well as parameters quoted in the draft ETSI standard. Present and future instruments were included into the study (conical scanned, cross-track nadir, and push-broom sensors). The studies clearly indicate that operation of the new service is not compatible to EESS applications. Several mitigation techniques have been proposed but so far, these have not resulted in acceptable sharing conditions.

The study within CEPT resulted in the conclusion that sharing between the car radars and EESS (passive) is not feasible. Activities concentrate on finding an alternative frequency band. Nevertheless, SARA claims that they would need to start implementation of the service in the band 21–27 GHz. This is due to the availability of sensors, which were designed for this band. SARA representatives have proposed the development of a new type of sensor, which will operate in a different band and that they intend to depart from the band covering the EESS (passive) allocation. It will now be necessary to find and agree on an alternative band and to develop a committing schedule for introduction and termination of the service. It is foreseen to fix a date after which no new equipment will be installed. Such a committing schedule could be made part of the licensing agreement issued by the frequency regulators. The EESS community could agree on this regulation recognising that:

- in the first years of service implementation there would be only small numbers of cars equipped with these radars, and

- EESS sensors of a new, more sensitive type (as included in the compatibility study) would only be implemented in a few years.

The FCC in the USA have issued a "First Report and Order" (ET Docket 98-153) on 22 April 2002 regarding the use of ultra-wideband transmissions including the use of this technology for "Vehicular Radar systems". Although this document concludes that no harmful interference will be caused to meteorological satellite measurements, it is expected that the associated spectrum masks and operation values used in this document are not giving the required protection to EESS usage in the band. It has, therefore, to be expected that the introduction of the new service will invalidate measurements of instruments operated on meteorological satellites. Wrong measurement values will be achieved and will invalidate not only the measurements in the 24 GHz band but also all other measurements of these instruments. This could result in a major degradation in meteorological processing based on these measurements.

A phased approach for the introduction of the Vehicle Radar System (VRS) has been proposed by reducing the output power of SRR equipment after certain dates to compensate for the growing number of operating devices and the related cumulative interference from serious high numbers of equipment. Although this could improve the sharing situation, there are still doubts whether this will give the required protection. It is also noted that the equipment will be operated under part 15 of FCC rules, i.e. as unlicensed equipment.

ITU has discussed the issue of UWB and has decided that a Task Group (TG 1/8) be established in Study Group 1 in order to urgently address the compatibility between UWB devices and radio communication services (Q.227/1), the spectrum management framework related to the introduction of UWB devices (Q.226/1), and appropriate measurement techniques for UWB devices.

Considering the criticality of this issue to the space-component of the GOS and to its all – weather sounding capability, CGMS members are invited to express their concerns to their national frequency administrations.

CGMS members were urged urged to discuss the potential problems caused by car radar systems operating in the band 21–27 GHz with their national frequency administrations.

### 5.3.4. IDCS Interference Tracking and Location System (TLS)

In CGMS XXX-USA-WP-22, the USA informed the CGMS members that the Phase 2 Proof of Concept demonstration of the applicability of the TLS technology to the NOAA GOES DCS has been completed. The Phase 2 Proof of Concept demonstration was performed on behalf of NOAA at the Wallops Command and Data Acquisition (WCDA) station in Wallops Station, Virginia. The results of the Phase 2 effort demonstrate that the TLS technology can geolocate fixed DCS platforms within the area of covisibility of the GOES-E and GOES-W satellites with typical accuracies of the order of ten miles. For platforms in motion, either on board maritime vessels or more likely on buoys subject to wave motions, the effect of the wave motion causes the Frequency Difference of Arrival (FDOA) to be poorly determined, resulting in significant errors in the reported geolocation. However, even for these signals the Time Difference of Arrival (TDOA) remains well determined, yielding accurately measured lines of position along which the transmitting platform lies.

Finally, a series of measurements were made on up-link signals (test transmitters) furnished by NOAA as “ground truth” signals. Calculated geolocation coordinates were provided for the measurements of these signals. NOAA evaluated these data against the known locations of the up-link transmitters to assess the performance of the TLS on these “unknown” signal sources. Interference location in the GOES DCS frequency band was successfully demonstrated using the TLS system. All unknown transmitters were located within the specified boundaries required by NOAA. Understanding the complexities of the DCS environment, NOAA believe the TLS system will benefit the management of its radio frequency resources and help to provide a better service for the DCS users and the GOES family. NESDIS continues to investigate the TLS and evaluate the benefits it has on the DCS service and the GOES system. Implementation of Phase 3 has not been determined. The USA continues to evaluate plans for operating the TLS in the GOES environment.

## 5.4. SHIPS, INCLUDING ASAP

CGMS XXX-WMO-WP-13 informed the meeting that the number of soundings taken in the frame of the ASAP was approximately 5300, similar to the average of most previous years. However, CGMS noted the substantial increase compared to the 4416 soundings obtained in 2000. This increase could largely be ascribed to a large enhancement in the number of soundings carried out by Japan, Germany and the Conference of National Meteorological Services in Europe (EUMETNET). At the same time, two countries (Russia and the USA) have, temporarily at least, ceased their ASAP activities. The total number of ASAP units operated in 2001 was 24; the operators were: Denmark (three units), EUMETNET (two units), France (four units), Germany (three units), Japan (seven units), Spain (one unit), Sweden-Iceland (one unit), United Kingdom (two units) and WRAP (one1 unit). The performance of ASAP operators remained quite stable. However, the communication efficiency experienced by Germany and Spain remains low and EUMETSAT is investigating the problem.

## 5.5. ASDAR

CGMS XXX-WMO-WP-09 informed the Group that although the Aircraft to Satellite Data Relay (ASDAR) programme peaked early in 1998 with 21 operational systems, there had been a substantial reduction in its size following the decommissioning of one more aircraft in November 2001. Two more aircraft are due to be decommissioned by the end of November 2002, leaving eight from the original 21 installed units. Three other aircraft are not reporting for various reasons associated with airline operating constraints but one is expected to return to operational status by the end of 2002. The level of technical support has been reduced further and a major section of support will cease completely in March 2003. Increasing data quality problems, whose cause has not been determined, are also a cause of concern. With eight installed units remaining after November 2002 and noting that there is considerable uncertainty whether the Saudi Arabian units will return to service, only six units will remain operational for the immediate future. It is also noted that the ASDAR Centre will close in March 2003. Consequently, the Aircraft Meteorological Data Relay (AMDAR) Panel, which carries responsibility for the ASDAR operational programme, decided at its recent annual meeting that the programme will continue to function in its present form for the next 12 months. CGMS satellite operators will be informed should there be any significant changes in the programme.

## 5.6. DISSEMINATION OF SATELLITE IMAGES VIA SATELLITE

CGMS XXX-WMO-WP-03 discussed the latest status for LRIT/LRPT conversion for satellites in polar and geostationary orbit. An analysis of the plans for LRIT conversion indicated in WMO Regions I (Africa) and VI (Europe) that there will be a two-year overlap starting in October 2003. WMO Regions II (Asia) and V (southwest Pacific) will have a two-year overlap starting in 2003. For WMO Regions III and IV (South, Central and North America including the Caribbean) during November 2002, GOES-East will be converted from WEFAX to LRIT transmission and will cease transmitting WEFAX data. The conversion of GOES-West to LRIT will be based on the needs of the users. The date for the GOES-West conversion will be announced as soon as it is practical. The Indian Ocean area (RA II) appears to have no overlap starting in 2003.

It should be recalled that CGMS members have already indicated to WMO their intention to provide for a three-year overlap. An analysis of the table for LRPT conversion shows that the morning (AM) satellite will start LRPT in 2006 while the afternoon (PM) satellite will transmit two datastreams (Advanced High Rate Picture Transmission (AHRPT) and X-band) starting in 2010. The FY-3 series will only transmit AHRPT and X-Band starting in 2004. Meteor-3M N2 will transmit LRPT starting in 2005.

There will be no transition period for the AM orbit or PM orbit separately and the present combined CGMS satellite operators' plans indicate that it may be necessary to have at least three different receiving stations to receive AM and PM satellite data. WMO also noted with both sadness and pride that NOAA N' will provide the last Automatic Picture Transmission (APT) service starting in 2007. For more than forty years, APT has been one of the best ambassadors the satellite community has had. The transition to digital broadcasts is a necessity but the meteorological community at large, will long remember the workhorse in space called APT.

**Table 5.6.1.: Status for LRIT Conversion, Satellites in Geostationary Orbit**
*(as of 13 October 2003)*

| Operator | Satellite | Launch (M/Y) | Service | Start | Stop |
|---|---|---|---|---|---|
| **EUMETSAT** | Meteosat-5 | 03/1991 | WEFAX | 03/91 | |
| | Meteosat-6 | 11/1993 | WEFAX | 11/93 | |
| | Meteosat-7 | 02/1997 | WEFAX | 07/97 | 12/03 |
| | MSG-1 | 1/2002 | LRIT | 10/02 | 2007 |
| | MSG-2 | 2003 | LRIT | 2004 | 2010 |
| | MSG-3 | 2008 | LRIT | 2008 | 2013 |
| **India** | INSAT I-d | 06/1990 | None | | |
| | INSAT II-a | 07/1992 | None | | |
| | INSAT II-b | 07/1993 | None | | |
| | INSAT II-e | --- | None | | |

| | | | | | |
|---|---|---|---|---|---|
| **Operator** | **Satellite** | **Launch (M/Y)** | **Service** | **Start** | **Stop** |
| **Japan** | GMS-5 | 03/1995 | WEFAX | 06/95 | 2003 |
| | MTSAT-1R | 2003 | WEFAX<br>LRIT | 2003<br>2003 | 2005<br>2008 |
| | MTSAT-2 | 2004 | LRIT | 2008 | 2013 |
| **USA** | GOES – 8 | 04/1994 | WEFAX | 11/94 | 04/2003 |
| | GOES – 9 | 05/1995 | WEFAX | 01/96 | 05/2003 |
| | GOES – 10 | 04/1997 | WEFAX | 06/97 | |
| | GOES – 11 | 05/2000 | WEFAX | 09/00 | |
| | GOES – 12 | 08/2002 | WEFAX/LRIT | 04/03 | |
| | GOES – N | 12/2004 | LRIT | | |
| | GOES – O | 2007 | LRIT | | |
| | GOES – P | 2008 | LRIT | | |
| **Russian Federation** | Elektro-1 | 11/94 | WEFAX | | |
| | Elektro-2 | 2003 | WEFAX | | |
| | Elektro-3 | TBD | LRIT | | |
| **China** | FY-2B | 06/00 | WEFAX | 01/01 | |
| | FY-2C | 2004 | LRIT | 2004 | |
| | FY-2D | 2006 | LRIT | 2006 | |
| | FY-2E | 2009 | LRIT | 2009 | |

**Table 5.6.2.: Status for LRPT Conversion, Satellites in Polar Orbit**
*(as of 13October 2003)*

| **Operator** | **Satellite** | **Launch (M/Y)** | **Service** | **Start** | **Stop** |
|---|---|---|---|---|---|
| **EUMETSAT** | Metop-1 | 12/2005 | LRPT | 2006 | |
| | Metop-2 | 12/2009 | LRPT | 2010 | |
| | Metop-3 | 06/2015 | LRPT | 2015 | |
| **USA** | NOAA-9 | 12/1984 | APT | 12/84 | 08/95 |
| | NOAA-12 | 05/1991 | APT | 05/91 | |
| | NOAA-14 | 12/1994 | APT | 12/94 | |
| | NOAA-15 | 08/1997 | APT | 08/97 | |
| | NOAA-16 | 09/2000 | APT | 09/00 | |

| Operator | Satellite | Launch (M/Y) | Service | Start | Stop |
|---|---|---|---|---|---|
| | NOAA-M | 04/2001 | APT | 04/01 | |
| | NOAA-N | 12/2003 | APT | 12/03 | |
| | NOAA-N' | 07/2007 | APT | 07/07 | |
| | NPP – NPOESS Preparatory Project | 10/2006 | HRD (X-Bamd) Only | | |
| | NPOESS-1 | 11/2009 | Tentative: AHRPT and X-band | | |
| | NPOESS-2 | 06/2011 | Tentative: AHRPT and X-band | | |
| | NPOESS-3 | 06/2013 | Tentative: AHRPT and X-band | | |
| | NPOESS-4 | 11/2015 | Tentative: AHRPT and X-band | | |
| | NPOESS-5 | 01/2018 | Tentative: AHRPT and X-band | | |
| | NPOESS-6 | 2019 | Tentative: AHRPT and X-band | | |
| **China** | FY-1C | 05/1999 | No APT or LRPT. CHRPT only | | |
| | FY-1D | 05/2002 | No APT or LRPT. CHRPT only | | |
| | FY-3A | 2004 | AHRPT and X-band only | | |
| | FY-3B | 2006 | AHRPT and X-band only | | |
| **Russian Federation** | Meteor 2-21 | 08/1991 | APT | 08/91 | |
| | Meteor 3-5 | 08/1991 | APT | 08/91 | |
| | Resourse-01-N4 | --- | APT | | |
| | Meteor 3M-1 | 2001 | APT | | |
| | Meteor 3M-2 | 2003 | LRPT | 2003 | |

The USA (CGMS XXX-USA-WP-11) LRIT system architecture consists of five processing domains (ground processing system) and a user terminal domain interconnected by various communications media. The LRIT ground processing system and five prototype user terminals were completed and have undergone extensive system integration testing. The units were delivered to NOAA in mid-September 2002. In September 2002, the development of the LRIT system was completed and system integration testing was initiated. The USA will employ a user terminal configuration that will allow users to select either a one-meter or two-meter antenna at 128 kbps data rate. The USA is evaluating alternatives for information elements to be included on the future LRIT datastream. Alternate WEFAX/LRIT transmissions will begin in January 2003 on GOES-East. The transition from current WEFAX to total LRIT services is projected to occur over a one to two year period for the GOES constellation (i.e., GOES East and GOES West). The USA encouraged CGMS members to attend the Direct Readout Conference for the Americas, held in Miami, Florida on 9–13 December 2002. For details of the presentations see http://noaasis.noaa.gov/miami02/program3.html

The USA (CGMS XXX-USA-WP-12) also provided an update on the development of the Code Division Multiple Access (CDMA) overlay system for the GOES IDCS/DCS. The objective of the CDMA Overlay Programme is to demonstrate that satellite-based CDMA carriers can co-exist with the Time Division Multiple Access (TDMA) users on the GOES DCS transponders. The USA contracted Science Applications International Corporation (SAIC) to design a prototype CDMA transmitter, develop a CDMA receive site (hub) and demonstrate the new capabilities at the WCDA station. The CDR was held on 26 February 2002 to review the design of the prototype system and discuss the development activities for using spread spectrum techniques to complement the GOES DCS service. The CDR addressed the specifications for the transmitter and the configuration for the receive site. A CDMA overlay demonstration and evaluation was scheduled at the Wallops CDA for 8–11 July 2002. SAIC performed system installation and checkout of the prototype CDMA processor and transmitters prior to the proof-of-concept demonstration. During the initial station integration testing, it was realised that the transmitters were not operating at the proper power level. The units were returned to the manufacturer for repair. A new date for the demonstration has not been determined.

The USA then provided an overview of the specifications for the LRIT receiver. CGMS XXX-USA-WP-14 described the technical specifications for operating a LRIT user station to capture the GOES digital broadcast. The USA LRIT receive station is designed to be interoperable with the planned JMA and EUMETSAT systems. The design of the LRIT user station is consistent with the design of the user terminals for using the recommended Consultative Committee on Space Data Systems (CCSDS) standard for packet telemetry. Each user station consists of an antenna, radio receiver, receiving processor and a workstation. The antenna is a parabolic dish antenna with no auto tracking. The down-link signal is received at 1691 MHz.

The signal may be filtered to reduce adjacent channel interference and/or amplified by a low-noise amplifier. Then it is down-converted to the receiver IF frequency. The IF signal is then demodulated in a Bi-phase Shift Keying (BPSK) demodulator and the baseband output to the receiving processor is a serial bit stream.

In CGMS XXX-USA-WP-15, the USA provided an update on the LRIT system transition and test plans. The USA has developed a transition and implementation plan for the LRIT that will originate on a GOES I-M spacecraft currently in storage. Tests of the LRIT datastream on the current GOES series were conducted during the last quarter of 2001 and in June 2002. Further tests of the new digital datastream are planned on non-operational satellites. NOAA's transition alternative consists of timesharing between WEFAX and LRIT on individual spacecraft for a limited time period (e.g., one to two years) followed by a total transition. Further, this alternative is described as a period of parallel operations for each of the two GOES satellites where both WEFAX and LRIT services would be simultaneously broadcast (i.e. timeshared GOES I-M transponder) for a specified transition period, followed by a full and permanent transition to full LRIT services.

CGMS XXX-USA-WP-34 presented details of LRIT system performance and link budgets. Initially, the LRIT will transmit at 128 kbps. Link calculations show the performance for a 1-meter dish and a 1.8-meter dish. The minimum performance goal is a $10^{-8}$ ber with a 3 dB margin. This is not achieved near the edge of coverage (e.g. low antenna elevation angles) using the smaller antenna. For both antennas the link margin of 3 dB is achieved at elevation angles above 15°. However, for the smaller antenna the performance of $10^{-8}$ ber is not achieved at 5° because of high scintillation loss. The performance of the LRIT communications link is dependent upon many assumptions concerning the spacecraft, user receiver, and atmospheric losses. In this document, conservative assumptions have been chosen in order to determine the worst-case performance of the communications link. In the link budget, an insertion loss of –1.0 dB is used to account for a front-end filter to reduce interference. User stations with about a 5° elevation angle may not be in an environment that would require the filter. In this analysis, the USA conservatively reduced the ideal coding gain from 9.4 dB to 7 dB. The ability of the concatenated coding to produce the full gain will be tested. If full coding gain is achievable, the link performance will increase by 2.4 dB. This is enough by itself to achieve a full 3 dB margin at 5° elevation during the initial operational phase and increase the margin to +2.3 dB at that range in the final operational phase.

## 5.7. Discussions by the Task Force on Integrated Strategy for Data Dissemination from Meteorological Satellites

CGMS XXX-WMO-WP-21 informed the Group that the CGMS Ad Hoc Task Force on Integration Strategy for Data Dissemination from Meteorological Satellites had met at WMO Headquarters, Geneva, Switzerland on 29 April 2002 in response to an action item from CGMS XXIX. The primary objective for the meeting was to review the concept, from a CGMS perspective, for data access from the future space-based component of the GOS. The Task Force meeting was held as a joint session with the OPAG IOS Expert Team on Satellite Systems Utilisation and Products, in order to provide the Expert Team with a CGMS perspective on the topic of Alternative Dissemination Methods (ADM).

The Task Force had noted that most CGMS satellite operators either had ADM in place or intended to use it in the near future. It was also noted that ADM were unique to each satellite operator and that commonality and coordination between them was very limited. The Task Force also reviewed the proposed WMO concept for ADM, as reported in the Final Report of the OPAG-IOS Expert Team on Satellite System Utilisation and Products (SSUP-4) and was in full agreement with the concept.

The Task Force also recommended, in order to avoid uncoordinated proliferation of ADM, that each satellite operator strive to co-ordinate plans towards convergence of planned systems, especially in a WMO region. Such convergence could only occur if CGMS established a dedicated working group to develop an overall strategy for convergence of planned ADM as well as an associated implementation plan. The CGMS Ad hoc Task Force had further recommended that its present draft terms of reference be institutionalised into a standing CGMS working group. The working group should meet on a regular basis and report progress made to each CGMS Plenary. The membership of the working group should include CGMS satellite operators and appropriate WMO CBS Open Programme Area Groups including Integrated Observing Systems and Information Systems and Services. It should address both geostationary and polar orbiting and both operational and R&D satellites. The strategy should take into consideration all users' temporal requirements for data.

CGMS agreed that the terms of reference for the Ad Hoc Task Force would serve as those for the new working group on Integrated Strategy for Data Dissemination from meteorological satellites.

CGMS XXX-WMO-WP-22 informed the Group about its activities related to ADM. WMO had agreed that access to satellite data and products by its members should be through a composite data access service comprised of both DB from satellite systems and ADM. ADM would be the baseline while DB reception would serve as back-up as well as for those WMO members unable to take advantage of ADM. CGMS noted that ADM branches were open to merging with other meteorological datastreams. For example, it would allow a seamless inclusion of data/product sets from polar and geostationary operational satellites as well as from relevant R&D satellites.

The USA (CGMS XXX-USA-WP-21) provided updates on POES and NPOESS data formats and frequencies. The USA is investigating the global distribution of high-resolution imager and sounder data in the GOES-R era. Considering the expected high data rates for the proposed instruments, the USA studied three global distribution options consisting of dedicated lines, GOES-R rebroadcast and commercial communications satellites.

Japan (CGMS XXX-JPN-WP-05) reported on the outcome of the Fourth Session of "Asia-Pacific Satellite Data Exchange and Utilisation (APSDEU)", hosted by JMA, on 13–15 March 2002. The purpose of the meeting was to promote the enhanced utilisation of satellite observation data of the Earth's environment in the Asia-Pacific region and to ensure satisfactory data exchange.

Concluding, Working Group I stressed the importance of standardisation of data formats and protocols to facilitate future interoperability of data from the various expected satellite systems, and generally endorsed the notion that, where feasible, efforts should be made to coordinate ADM, especially, within a WMO region.

A Global overview showing the coordination of data formats and frequency planning for polar orbiting satellites is presented in table 5.7.

Table 5.7 Coordination of Data Formats for Polar-Orbiting Satellites Coordinated within CGMS (as of 13 October 2003)

| Satellite | Service | Start | EOL | Eq. Cross-time | Freq (MHz) | BW MHz | Data rate (Mb/s) |
|---|---|---|---|---|---|---|---|
| Metop-1 | LRPT | 2006 | 2011 | 0930 | 137.9 | .150 | .072 |
| Metop-2 | LRPT | 2010 | 2015 | 0930 | 137.9 | .150 | .072 |
| Metop-3 | LRPT | 2015 | 2020 | 0930 | 137.9 | .150 | .072 |
| Metop-1 | AHRPT | 2006 | 2011 | 0930 | 1701.3 | 4.5 | 3.5 |
| Metop-2 | AHRPT | 2010 | 2015 | 0930 | 1701.3 | 4.5 | 3.5 |
| Metop-3 | AHRPT | 2015 | 2020 | 0930 | 1701.3 | 4.5 | 3.5 |
| Metop-1 | GDS | 2006 | 2011 | 0930 | 7800 | 63 | 70 |
| Metop-2 | GDS | 2010 | 2015 | 0930 | 7800 | 63 | 70 |
| Metop-3 | GDS | 2015 | 2020 | 0930 | 7800 | 63 | 70 |
| NPP | HRD | 2006 | 2010 | 1030 D | 7812 | TBD | 15 |
| NPP | SMD | 2006 | 2010 | 1030 D | 8212.5 | 375 | 300 |
| NPOESS-1 | LRD | 2009 | 2015 | 0930 D | 1706 | 8.0 | 3.88 |
| NPOESS-2 | LRD | 2011 | 2018 | 1330A | 1706 | 8.0 | 3.88 |
| NPOESS-3 | LRD | 2013 | 2019 | 0530 D | 1706 | 8.0 | 3.88 |
| NPOESS-4 | LRD | 2015 | 2021 | 0930 D | 1706 | 8.0 | 3.88 |
| NPOESS-5 | LRD | 2018 | 2024 | 1330A | 1706 | 8.0 | 3.88 |
| NPOESS-6 | LRD | 2019 | 2025 | 0530 D | 1706 | 8.0 | 3.88 |
| NPOESS-1 | HRD | 2009 | 2015 | 0930 D | 7812/7830 | 30.8 | 20 |
| NPOESS-2 | HRD | 2011 | 2018 | 1330A | 7812/7830 | 30.8 | 20 |
| NPOESS-3 | HRD | 2013 | 2019 | 0530 D | 7812/7830 | 30.8 | 20 |
| NPOESS-4 | HRD | 2015 | 2021 | 0930 D | 7812/7830 | 30.8 | 20 |
| NPOESS-5 | HRD | 2018 | 2024 | 1330A | 7812/7830 | 30.8 | 20 |
| NPOESS-6 | HRD | 2019 | 2025 | 0530 D | 7812/7830 | 30.8 | 20 |
| NPOESS-1 | SMD | 2009 | 2015 | 0930 D | 25650 | 300 | 150 |

| Satellite | Service | Start | EOL | Eq. Cross-time | Freq (MHz) | BW MHz | Data rate (Mb/s) |
|---|---|---|---|---|---|---|---|
| NPOESS-2 | SMD | 2011 | 2018 | 1330A | 25650 | 300 | 150 |
| NPOESS-3 | SMD | 2013 | 2019 | 0530 D | 25650 | 300 | 150 |
| NPOESS-4 | SMD | 2015 | 2021 | 0930 D | 25650 | 300 | 150 |
| NPOESS-5 | SMD | 2018 | 2024 | 1330A | 25650 | 300 | 150 |
| NPOESS-6 | SMD | 2019 | 2025 | 0530 D | 25650 | 300 | 150 |
| NOAA-15 | APT | 1998 | 2001 | 0730 | 137.5 – 137.62 | .034 | .017 |
| NOAA-15 | BTX | 1998 | 2001 | 0730 | 137.35 – 137.77 | | .00832 |
| NOAA-15 | HRPT | 1998 | 2001 | 0730 | /1702.5 | 2.66 | .665 |
| NOAA-15 | GAC | 1998 | 2001 | 0730 | 2247.5 | 5.32 | 2.66 |
| NOAA-16 | APT | 2000 | 2004 | 1400 | Failed | .034 | .017 |
| NOAA-16 | BTX | 2000 | 2004 | 1400 | 137.35 – 137.77 | | .00832 |
| NOAA-16 | HRPT | 2000 | 2004 | 1400 | 1698 | 2.66 | .665 |
| NOAA-16 | GAC/LAC | 2000 | 2004 | 1400 | 1698/1702.5<br>(1707 Failed) | 5.32 | 2.66 |
| NOAA-17 | APT | 2002 | 2005 | 1000 | 137.50 – 137.62 | .034 | .017 |
| NOAA-17 | BTX | 2002 | 2005 | 1000 | 137.35 – 137.77 | | .00832 |
| NOAA-17 | HRPT | 2002 | 2005 | 1000 | 1698 | 2.66 | .665 |
| NOAA-17 | GAC/LAC | 2002 | 2005 | 1400 | 1698//1702.5/1707 | 5.32 | 2.66 |
| NOAA-N | APT | 2004 | 2008 | 1330 | 137.50 – 137.62 | .034 | .072 |
| NOAA-N | BTX | 2004 | 2008 | 1330 | 137.35 – 137.77 | | .00832 |
| NOAA-N | HRPT | 2004 | 2008 | 1330 | 1698/1707 | 2.66 | .665 |
| NOAA-N | GAC/LAC | 2004 | 2008 | 1330 | 1698//1702.5 | 5.32 | 2.66 |
| NOAA-N’ | APT | 2008 | 2012 | 1330 | 137.50 – 137.62 | .034 | .017 |
| NOAA-N’ | BTX | 2008 | 2012 | 1330 | 137.35 – 137.77 | | .00832 |
| NOAA-N’ | HRPT | 2008 | 2012 | 1330 | 1698/1707 | 2.66 | .665 |
| NOAA-N’ | GAC/LAC | 2008 | 2012 | 1330 | 1698//1702.5/1707 | 5.32 | 2.66 |
| FY-1C | CHRPT | 1999 | 2001 | 0830 | 1698-1710 | 5.6 | 1.3308 |

| Satellite | Service | Start | EOL | Eq. Cross-time | Freq (MHz) | BW MHz | Data rate (Mb/s) |
|---|---|---|---|---|---|---|---|
| FY-1D | CHRPT | 2002 | 2004 | 0900 | 1698-1710 | 5.6 | 1.3308 |
| FY-3A | AHRPT | 2004 | 2007 | 1010 | 1698-1710 | 5.6 | 4.2 |
| FY-3B | AHRPT | 2006 | 2009 | 1010 | 1698-1710 | 5.6 | 4.2 |
| FY-3C | AHRPT | 2008 | 2011 | 1010 | 1698-1710 | 5.6 | 4.2 |
| FY-3D | AHRPT | 2010 | 2013 | 1010 | 1698-1710 | 5.6 | 4.2 |
| FY-3E | AHRPT | 2012 | 2015 | 1010 | 1698-1710 | 5.6 | 4.2 |
| FY-3A | MPT | 2004 | 2007 | 1010 | 7750-7850 | 35 | 18.2 |
| FY-3B | MPT | 2006 | 2009 | 1010 | 7750-7850 | 35 | 18.2 |
| FY-3C | MPT | 2008 | 2011 | 1010 | 7750-7850 | 35 | 18.2 |
| FY-3D | MPT | 2010 | 2013 | 1010 | 7750-7850 | 35 | 18.2 |
| FY-3E | MPT | 2012 | 2015 | 1010 | 7750-7850 | 35 | 18.2 |
| FY-3A | DPT | 2004 | 2007 | 1010 | 8025-8215 / 8215-8400 | 120 | 93 |
| FY-3B | DPT | 2006 | 2009 | 1010 | 8025-8215 / 8215-8400 | 120 | 93 |
| FY-3C | DPT | 2008 | 2011 | 1010 | 8025-8215 / 8215-8400 | 120 | 93 |
| FY-3D | DPT | 2010 | 2013 | 1010 | 8025-8215 / 8215-8400 | 120 | 93 |
| FY-3E | DPT | 2012 | 2015 | 1010 | 8025-8215 / 8215-8400 | 120 | 93 |
| Meteor 3M N1* | Raw | 2001 | 2004 | 0915 | 466.5 | 3 | 0.080 |
| Meteor 3M N1* | Raw | 2001 | 2004 | 0915 | 1700 | 2 | 0.665 |
| Meteor 3M N1* | Raw | 2001 | 2004 | 0915 | 8192 | 32 | 15.36 |
| Meteor 3M N2 | LRPT | 2004 | 2011 | 1030 | 137.89 / 137.1 | 0.15 | 0.064 |
| Meteor 3M N2 | HRPT | 2004 | 2011 | 1030 | 1700 | 2 | 0.665 |
| Meteor 3M N2 | Raw | 2004 | 2011 | 1030 | 8192 | 32 | 15.36 |

# 6. SATELLITE DATA CALIBRATION AND METEOROLOGICAL PRODUCT EXTRACTION

## 6.1. INTRODUCTION

Quantitative application of satellite observation requires the absolute calibration of the observed raw radiance data. Calibration techniques for the thermal IR channels of the current generation of meteorological satellites rely on on-board calibration employing a black-body or on vicarious techniques where calculated radiances are associated with raw radiances. It is clear that a proper onboard calibration is the recommended solution. First, it is a physically sound concept that directly tries to calibrate the complete remote sensing system onboard the satellite with a reference radiance target. Second, it provides, in principal, the possibility to calibrate the satellite data as often as required (e.g. for individual imaging lines or sounding tracks). In reality this seemingly flawless concept of on-board calibration is compromised by technological constraints, e.g. for geostationary calibration it is difficult to calibrate the complete optical chain and parts of the optical properties of the fore-optics need to be modelled. Until May 2000 Meteosat IR and WV calibration has relied on a vicarious technique, i.e. no onboard system has been used.

Further uncertainties in absolute calibration arise primarily from:

(i) transfer of the calibration of a primary standard (at, e.g., the National Institute of Standards and Technology) to the secondary standard in the laboratory where the instruments are tested;

(ii) transfer from the secondary standard to the instrument's blackbody during pre-launch tests,

(iii) limitations in the accuracy of characterising optical properties of the satellite instruments (e.g. spectral response functions) at ground before launch, iv) unknown ageing effects of the satellite instrument components.

Details of absolute and vicarious calibration of current geostationary and polar-orbiting satellite sensors are described in the literature and the reader is referred to the following papers:

Onboard calibration: Menzel et al., 1981, …..

Vicarious calibration: Schmetz, 1989; van de Berg et al., 1995, Gube et al., 1996, …..

The solar channels of meteorological satellites are not generally calibrated but rather rely on infrequently conducted vicarious techniques. Vicarious calibration methods rely on an independent estimation of the radiances observed by the instrument. Three different techniques can be envisaged for the estimation of the incoming radiance:

(i) satellite inter-comparison, (ii) airborne calibration campaigns, and (iii) simulation of the radiance observed by the satellite with a radiative transfer model (RTM). Which method is used has to be based on a judicious consideration of calibration requirements and constraints.

The requirements on calibration accuracy translate into the need to develop an absolute calibration method that includes a reliable estimation of the calibration accuracy.

Requirements on precision or monitoring of trends further impose that the method must be applied on a regular basis. The latter also suggests a method that is inexpensive to operate and can be applied throughout the entire lifetime of a satellite series. Vicarious calibration based on the monitoring of stable targets seems to be a promising way to go. Regular satellite cross-calibration would increase the confidence in the calibration. Infrequent and high-quality aircraft campaigns would provide highly accurate anchor points in the calibration monitoring.

## 6.2. Data Calibration Techniques of CGMS Members

### 6.2.1. EUMETSAT

The current calibration of the Meteosat IR channel is performed using ancillary information received routinely via the Global Telecommunications System of the World Meteorological Organisation. Sea surface temperatures from NESDIS and atmospheric temperature and moisture from the European Centre for Medium Range Weather Forecasts are used; these sea surface temperatures are a blend of conventional observations (e.g. buoys), satellite observations (e.g. NOAA polar-orbiting spacecraft) and climatology. The Meteosat calibration is performed in two independent steps: first an instantaneous vicarious IR calibration is derived with a constrained regression analysis from cloud-free sea surface observations (raw radiances) and calculated radiances using ECMWF short-term forecasts profiles and NESDIS SST. From the instantaneous calibration coefficient the operational calibration is determined via a statistical procedure that reduces short-term fluctuations in the calibration coefficient. This statistical process is different during eclipse periods. A more detailed description has been provided in Gube et al. (1996).

More recently studies have been performed utilising the blackbody onboard of Meteosat-7 for absolute calibration. Preliminary results are encouraging and show that i) the blackbody calibration can be used and ii) provides more stable results than the vicarious calibration. It also indicates that the current vicarious calibration is adequate.

Gube, M., V. Gärtner and J. Schmetz, 1996: Analysis of the operational calibration of the Meteosat infrared- window channel. Meteorol. Appl., 3, 307 – 316.

### 6.2.2. India

Calibration of IR Channel of INSAT is done on lines similar to the approach described in the technical Report No. NOAA-NESS-107 (upgraded) entitled “Data Extraction and calibrations”. Data from the visible channel is only normalised and compressed.

**Data calibration technique**

Ten bit INSAT IR data is calibrated using a two-point calibration algorithm. A warm black body whose temperature is monitored by five PRTs gives warm end point. The other point (cold end) is deep space whose temperature is taken as 40 K.

The Radiometric counts for cold and warm ends are available in data stream.

Radiance (R) = g∗C+I ----------- (1)

Applying this equation (1) for cold and warm ends gives:

$R_{Sp} = g*C_{Sp} + I$ } R is radiance

$R_{BB} = g\ C_{BB} + I$ } g is gain (slope)

$$g = \frac{R_{BB}-R_{Sp}}{C_{BB} - C_{Sp}}$$

} C is count

} I is intercept

The video counts also include zero offset (25 ± 5 counts) which must be subtracted from raw counts before processing of data.

Intercept I = $R_{BB} - g*C_{BB}$

= $(R_{BB} - R_{BB} - R_{Sp})\ C_{BB\,/}\ (C_{BB}-C_{Sp})$

Subscripts $_{Sp}$ and $_{BB}$ stand for space and black body respectively.

For converting counts to Temperature, the counts are first converted to radiance after subtracting zero offset. Finally Radiances are converted to Temperature by inverting Plank's function.

While calibration for IR is done with full resolution 10 bit data, only normalisation is done for visible counts. In case of IR, 10 bit counts are compressed to 8 bit by a compression scheme, which is configurable and ensures full temperature resolution in SST region and relatively coarser resolution outside SST region. The 8-bit data is then inverted (NOT.A). In case of visible the data is simply compressed.

The compression scheme has been changed in the Upgraded data processing system to be installed in August-September, 2000. The new scheme will ensure same temperature LUT for all ingests. The enhancements will not be dependent on calibration and a scan with a particular temperature will show similar picture in different ingests. Meteorological parameters derived from INSAT are CMVs, OLR QPE and SST. OLR, QPE and SST. OLR, QPE and SST are being at 10 grid interval.

### 6.2.3. Japan

The infrared data calibration uses the relation among VISSR brightness level, the sensor output voltage and radiation energy. The conversion table from S-VISSR brightness levels to brightness temperatures has already been prepared and distributed to the MDUS users by "THE GMS USER'S GUIDE". But because the table is no consideration of diurnal and annual variations of the relationship between brightness levels and brightness temperature, a calibration information block is added in the documentation sectors of S-VISSR 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.

The visible data calibration uses the relation among VISSR brightness level, sensor output voltage and Albedo. The fixed conversion table between brightness levels and Albedo is prepared. JMA reported its operational calibration in CGMS XXVII Working Paper JPN-WP-17.

### 6.2.4. PRC

#### 6.2.4.1. Calibration in orbit

The calibration in orbit of FY-2 satellite radiometer includes the ground calibration before launch and the on orbit calibration after launch. The ground calibrations for IR and Water Vapor channels are made with simulated space environment in lab, it derives the correlation between radiometer output and radiation brightness of object. As for VIS channel, it adopts the field calibration to derive the correlation between radiometer output and the albedo of Earth-atmosphere system based on the calculation model. The above-mentioned correlation can be made as a conversion table between the brightness temperature (or albedo) and counting value for user's reference.

After the satellite has been launched into a geostationary orbit, some changes in the optical and electronic components of the radiometer occur due to the influence of harsh space environment. So it is necessary to make the on orbit calibration with the changes in the characteristics of the calibration. The calibration is done by extracting calibration information first from telemetry data and image frame, then these information are sent to the data processing centre for further handling and generating the conversion table of calibration correction. Finally the calibration correction on image data counting value is executed by the S/DB installed in CDAS.

#### 6.2.4.2. Relative calibration (cross calibration)

FY-2 satellite is a spin-stabilised geostationary meteorological satellite, limited by observing method, the on-orbit calibration of infrared channels is only a relative calibration. Using the result of pre-launch laboratory calibration transferring relative calibration to absolute calibration is accomplished in some extent, but it is less precise. Inter-satellite relative calibration (or cross calibration) is a good approach to improve precision. NSMC studied FY-2 satellite relative calibration method using both GMS-5 and NOAA satellites and experiments have been done on FY-2 satellite IR channel.

The relative calibration is performed on the FY-2 satellite IR channel on the basis of GMS-5 satellite VISSR observation. To ensure the calibration is precise, the difference in observing method of the two satellites must be considered and the matching and correction have been performed on geometric characteristic, time and spectral characteristic of observation.

The relative calibration between FY-2 and NOAA satellite is performed for the infrared channel of FY-2 /VISSR and NOAA/AVHRR channel 4. The relative calibration method relies on simulation relationship corresponding to the radiance of FY-2 IR channel and the radiance of NOAA AVHRR IR channel. These two kinds of sensors have almost the same spectrum response. So it is possible to use the same scene from both satellites with the same satellite zenith angle and the nearest scanning time, to build up the matched database after screening out the clouds and making the spatial resolution uniform. After that, relative calibration relationship of these two corresponding IR channel's radiance can be acquired according to the different satellite zenith angle.

As the NOAA IR channel can complete an absolute calibration with a precision of 1K, generally, better results are obtained when the NOAA satellite is used, rather than GMS-5 to calibrate the FY-2 IR channel.

#### 6.2.4.3. Vicarious calibration

**Vicarious calibration of FY-2 satellite water vapour channel.**

FY-2 is a spin-stabilised geostationary meteorological satellite. Limited by its structure, the calibration optic path for infrared and water vapor channels of on-board radiometer does not include the front optics, so the in-flight calibration is only a relative calibration and a transformation from relative calibration to absolute calibration is required. It is an important method to take advantage of the vicarious calibration to accomplish absolute calibration.

Using radiosonde data, in the light of LOWTRAN 77 radiative transfer code calculated the radiance and fitted the calibration coefficients for corresponding digital counts of satellite radiometer. But around the equinox eclipse, characterised by rapid temperature variations in the satellite, the relationship of the radiometer calibration changes correspondingly. Considering the effects in the eclipse period, we performed water vapor channel vicarious calibration combined with in-flight calibration.

**Calibration using test sites**

Two radiometric calibration test sites have been established in China, one is the Dun Huang Gobi Desert test site, the other is the Qing Hai Lake test site. The Dun Huang site is used for radiometric calibration of visible and near-infrared channels of sensors, whilst the Qing Hai Lake site is used for the calibration of thermal infrared channel sensors. From June to August 1999 synchronous observations of the sites were made by the FY-1C satellite. The vicarious calibration for the CBERS satellite will be carried out in 2001.

### 6.2.5. USA

The meteorological satellite radiometers calibrated by NOAA/NESDIS include the AVHRR (Advanced Very High Resolution Radiometer), the HIRS (High resolution Infrared Radiation Sounder), and the AMSU-A (Advanced Microwave Sounding Unit-A), which are carried on the NOAA polar-orbiting system of satellites, and the Imager and the Sounder on the GOES (Geostationary Operational Environmental Satellite) system of satellites. The on-orbit calibration procedures for the polar-orbiting satellite instruments are described fully by Kidwell (1999). Specific calibration procedures, both pre-launch and on orbit, for the AMSU-A are described by Mo (1995, 1996). On-orbit calibration procedures for the geostationary instruments are documented by Weinreb et al.  (1997, 1999).

**Thermal infrared and microwave channels.** The thermal infrared and microwave channels of all these instruments are calibrated on orbit from data acquired during views of space and an on-board warm blackbody. The blackbody is in front of the scan mirror (infrared) or the reflector (microwave) and fills the instrument's aperture, thereby providing a full-system calibration. The nominally linear relationship between the incident radiant intensity and instrument output, the "calibration function," may actually be slightly non-linear and is approximated by a quadratic. The quadratic term, whose coefficient is determined before launch, contributes a few tenths of 1% of the radiance in many of the HgCdTe detectors but is completely negligible in the InSb detectors.

In the case of the GOES instruments, the angle of incidence of the incoming radiation at the scan mirror varies with east-west scan angle, causing an east-west variation in mirror reflectance in the infrared channels and, hence, an east-west variation in instrument throughput. This phenomenon is accounted for in the calibration by including the radiative transfer at the scan mirror, as is documented in Weinreb et al.(1997). The emissivity of the scan mirror as a function of scan angle, which is necessary information in the processing, is determined immediately after the launch and periodically thereafter from data taken as the instruments scan east-west across the full width of the instrument's field of regard on space above the north pole and below the south pole.

For the both the POES and GOES infrared instruments, the uncertainty in the absolute calibration was estimated to be approximately 0.5K in the long wave infrared channels and 0.6K in the shortwave channels. For the GOES, however, solar heating and scattered solar radiation cause uncompensated errors as large as 1K in short wave-channel observations during the hours near satellite midnight for approximately six months of each year. For the GOES instruments, radiometric precision, e.g., variability from scan line to scan line or frame to frame (not at satellite midnight), is estimated from on-orbit observations to be between 0.05K and 0.18K (rms), depending upon channel, for scenes at 300K.

The effect of solar contamination in the infrared channels of the polar-orbiting radiometers in terminator regions and terminator orbits, and the impact on sea surface temperature retrievals, are documented by Cao et al. (2001, 2003). Solar contamination occurs when the sun is on the horizon at the spacecraft. In this situation the sun may illuminate the blackbody and the fore-optics, and scattered light may contaminate the Earth view at large scan angles. The effect is most significant for shortwave channels, but it also affects the longwave due to the thermal lag between the radiative temperature of the blackbody skin and the PRT-sensed bulk temperature of the blackbody that occurs with solar illumination of the blackbody.

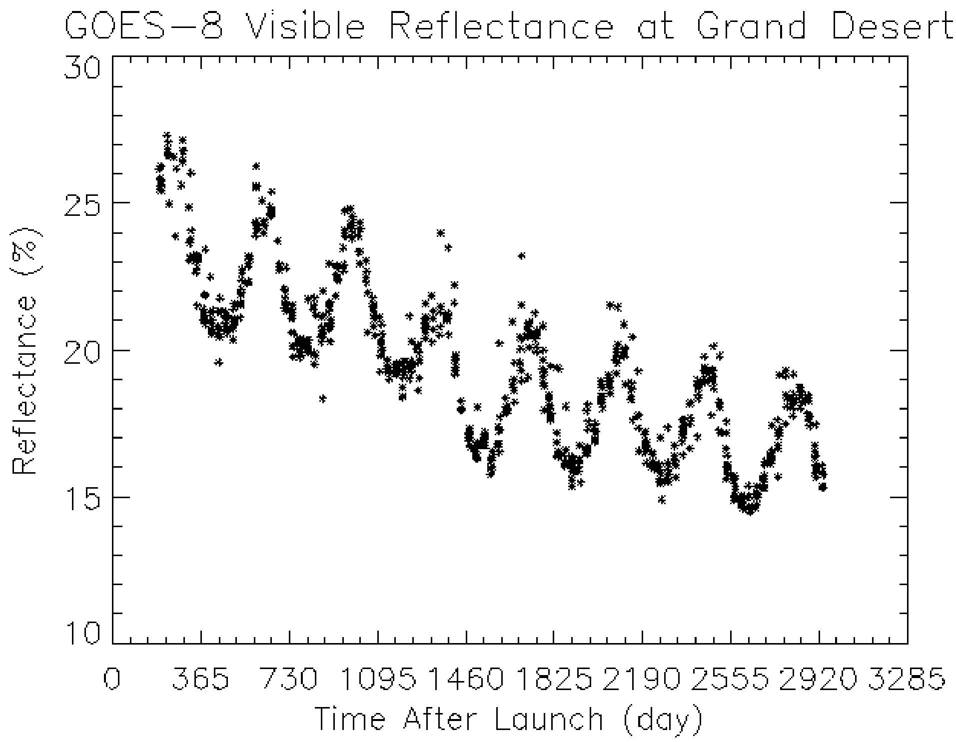
**Visible and near-infrared channels**. The visible and near-infrared channels on the AVHRR and the GOES Imager, lacking on-board calibration devices, are calibrated vicariously on orbit with stable earth targets, celestial targets, and calibrated radiometers as references.

For the AVHRR, the operational calibration is based primarily on stable earth targets, as described by Rao et al. (1999), with ongoing refinements. The basic assumption is that the reflectance of a stable earth target does not change over time, so it can be used as source of calibration. One recent modification is the recognition that the reflectance of stable earth targets, while stable year to year, varies within a year with solar zenith angle, i.e., the surface reflectance is bi-directional. Work is also underway to eliminate cloud contamination, to account for the non-homogeneity of the surface reflectance, and to reconfirm the reference reflectance of the target (its absolute calibration). Eventually, this technique will be applied to other stable earth targets at various geographic locations and with different reference reflectances to minimize the atmospheric (ozone, aerosol, water vapor) and instrument (dual slope) effects on calibration.

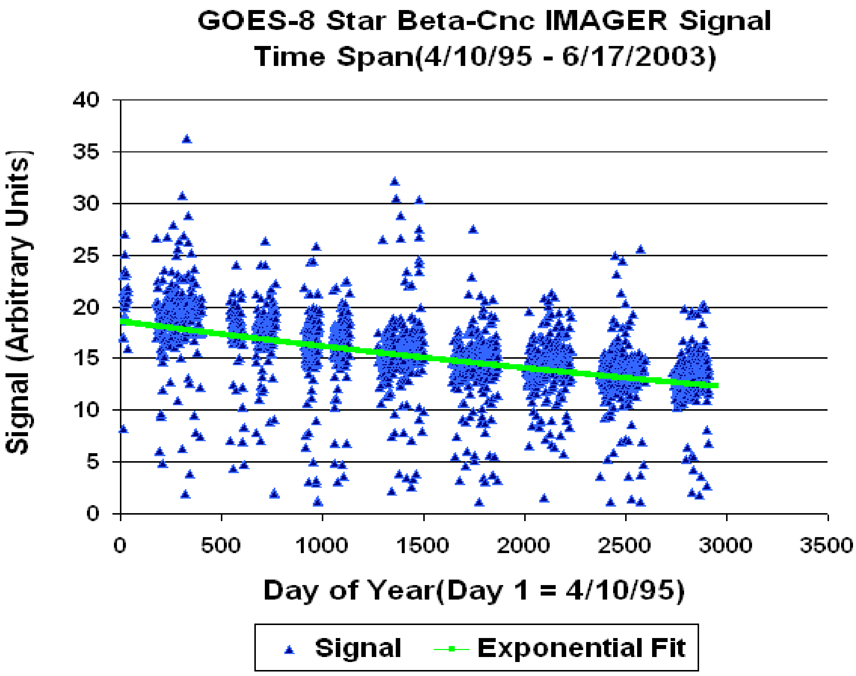
The calibration coefficients for the NOAA-16 AVHRR have been updated monthly since February 2003 from observations of the Libyan Desert (21°N -23°N, 28°E-29°E). For channel 1 (0.58-0.68 μm), the prelaunch calibration over-estimates the reflectance by a few percent immediately after launch, and afterwards the degradation has been moderate (1.3%±0.1% per year). For channel 2 (0.725-1.0 μm), the prelaunch calibration initially under-estimates the reflectance by a few percent ("the post-launch drop-off"), and the degradation rate has been higher (3.1%±0.3% per year). For channel 3A (1.58-1.64 μm), the degradation (0.3%±0.1% per year) is barely noticeable. Similar initial biases have also been found for the NOAA-17 AVHRR, but the degradation rates have not been determined as of this writing (July 2003).

Calibration of the AVHRR based on NASA's EOS/MODIS (Heidinger et al., 2002; also see section 6.3.3) offers unique advantages, even though it can be done only in summer months. The visible and near-infrared channels of the MODIS are calibrated on board. By matching individual pixels from the two satellite images, we transfer the MODIS calibration to the AVHRR. In July 2003, the data in channel 3A of the NOAA-16 AVHRR were collected for five scenes collocated with MODIS/Terra. (Since the spring of 2003, the data in channel 3A of the NOAA-16 AVHRR have not been collected in routine operations.) This type of data collection has been planned for future years to facilitate MODIS-based calibration. Inter-satellite calibrations involving MODIS/Aqua and NOAA-17 will also be studied in the future.

For the GOES Imager, the calibration utilizes several approaches. The first is based on a transfer from the MODIS, as described by Wu, 2003. The basic idea is to match histograms of image data from the two satellites. This technique has been used to provide instant MODIS-based calibration updates for the GOES-8, -10, and -12 Imagers. The calibration can be repeated every nine days, from which the degradation rate can also be estimated. Calibration based on a stable earth target has also been applied to GOES, with the Grand Desert in Sonora, Mexico, (32°21'N, 114°39'W) as the target. Although the reflectance of that target has not been convincingly determined, it is still useful for providing a relative calibration. The following figure shows eight years of GOES-8 observations of the Grand Desert, from which we estimated the degradation rate of the GOES-8 Imager's visible channel to be 5.8% per year for the 8-year period. The degradation seems to slow down for the last few years, so an analysis of only the later years' data may result in a lower degradation rate.




The celestial technique for determining the rate of degradation of the responsivity in the visible channel of the GOES Imager exploits observations of stars that are routinely made for another purpose--to determine the attitude and orbit of the GOES. The principles underlying the use of star observations to infer GOES visible-channel responsivity degradation are described in Bremer et al. (1998). The basic idea is that for a star whose brightness is invariant with time, any change in amplitude of the Imager's output on viewing the star must represent a change in the Imager's responsivity. The figure here is an example of a time series of observations of signal amplitude from one star.




From such data from 40 stars, we determined that the degradation rates through June 2003 for the GOES-8 and GOES-10 Imager visible channels were 5.0%/yr ∀0.1%/yr and 6.4%/yr ∀ 0.1%/yr, respectively. (The quoted uncertainties are only the statistical uncertainties; any difficulties in the technique itself will increase the total uncertainty.) Work is currently underway to improve the technique by reducing the scatter in the observations. Complete up-to-date results can be viewed at http://www.oso.noaa.gov/goes/goes-calibration/visible-channel.htm.

**References:**

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Weinreb, M.P., M. Jamieson, N. Fulton, Y. Chen, J.X. Johnson, C. Smith, J. Bremer, and J. Baucom, 1997: Operational calibration of GOES-8 and -9 imagers and sounders, *Applied Optics*, **36**, pp. 6895-6904. Also at http://www.nnic.noaa.gov/SOCC/page1.html.

Weinreb, M.P., R.X. Johnson, J.G. Baucom, and J.C. Bremer, 1999: GOES 8-10 calibration experience*, Adv. Space Res*., **23**, pp. 1367-1375.

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## INTER-CALIBRATION ACTIVITIES OF CGMS MEMBERS

Satellite data inter-calibration is beneficial for two reasons:

i) it will identify problems and increase the confidence in the operational calibration of individual satellites

ii) It provides the basis for a normalised calibration, which is a prerequisite for derivation of global products from different satellites. Normalisation is done with respect to a particular satellite, e.g. a polar-orbiting satellite.

The goal is to arrive at an inter-calibration for the IR window channels within about 1 K, which is the typical error, claimed for current operational satellite calibration. This can only be achieved if differences in observed target areas, viewing geometry, spectral response and collocation in time and space are properly considered and corrected.

Various approaches for inter-calibration of different sensors on different platforms have been investigated (Menzel, Schmetz, and Tokuno, 1998). The CGMS members have been collaborating to define techniques for cross-calibration of all the geostationary and polar-orbiting sensors. Initial focus has been on comparing the infrared window radiances measured by these systems; the goal is calibration within 1 K for IR and WV bands.

Inter-calibration requires consideration of (a) collocation in space and time of the measurements from the two sensors, (b) spectral response differences, (c) spatial resolution differences, (d) viewing angle differences, (e) day night differences in the calibration, (f) cloud contamination of the radiances, (g) scene uniformity, and (h) statistical significance of the sample must be adequate. These aspects of the inter-calibration are handled in various ways from one algorithm to another.

The purpose of the CGMS inter-calibration program was to quantify the relative agreement of IR window brightness temperatures on the operational meteorological satellites. This has been achieved, however it is clear that further work is warranted. Routine, if not operational satellite inter-calibrations, should be pursued; the advantages would be manifold, as it would benefit:

- satellite operators by keeping track of the operational calibration

- operational users by providing an independent and immediate check of the relative performance satellite calibrations

- Research users interested in climatological and multi-satellite applications by providing a relative assessment of the long-term consistency of operational satellite calibration. This would be appreciated by established research programmes such as ISCCP which have already established their own satellite inter-calibration or normalisation work (Brest and Rossow, 1992; Desormeaux et al., 1993). Continuation of such work is required since it will provide independent verification of the inter-calibration at the operational centres.

To date users of satellite data have had to make their own calibration adjustments. The International Satellite Cloud Climatology Program (ISSCP) is an illustrious example; ISCCP has produced a multi-year, multi-satellite calibrated data set by expending considerable energy to inter-compare and adjust satellite infrared window and visible radiance measurements from the past fifteen years. ISCCP is a research effort with a finite lifetime; it can not and should not assume responsibility for the continued production of such a calibrated data set. Such an activity needs to be embraced by the satellite operating agencies.

**References:**

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Menzel,W.P., J. Schmetz, and M. Tokuno, 1998: Program for Intercalibration of GMS, GOES, and Meteosat, versus HIRS and AVHRR Infrared Radiances. Report of the 26th meeting of the CGMS held 6 – 10 July 1998 in Nikko, Japan. EUMETSAT publication.

### 6.3.1. EUMETSAT

EUMETSAT has developed a satellite inter-calibration technique comparing Meteosat measurements with collocated NOAA-AVHRR or HIRS observations or with geostationary radiance observations from either GOES or another Meteosat satellite. The method described in Gube and Schmetz (1997) has been implemented and tested and is ready to be used routinely. The IR inter-calibration is detailed in König et al. (1999). The method uses target areas from two satellites collocated in time and space, corrects for differences in the spectral response functions, and considers the effects of different viewing geometry.

Results can be summarised as:

- cross-calibration between Meteosat-7 and HIRS IR window channels gives an agreement within 2% (bias for case studies for overpasses) or about 1.2 K at 290 K.

- cross-calibration between Meteosat-7 and AVHRR channel-4 on NOAA 14 is within 1 % or 0.6 K at 290 K.

- cross-calibration between Meteosat-7 and AVHRR channel-5 on NOAA 14 is within 2 % or or 1.2 K at 290 K.

**References:**

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König, M., J. Schmetz and S. Tjemkes, 1999: Satellite intercalibration of IR window radiance observations. Adv. Space Res., 23, No. 8, 1341 – 1348.

### 6.3.2. Japan

The Meteorological Satellite Center (MSC) has studied the intercalibration of several radiance observations using the infrared window channels aboard GMS-5 and the spectrally similar AVHRR channels onboard NOAA-14. Based upon the results of these studies, intercalibration between MTSAT-1R infrared channels and AVHRR and HIRS similar channels onboard NOAA satellites is planned. The method described in Gunshor et al (1999), which was used in the previous research, will be applied. The results will be compared, and posted on the MSC web site in real-time, in order to monitor temporal fluctuations of MTSAT-1R calibration.

### 6.3.3 USA

**Geostationary/Polar Orbiter Intercalibration**

The NOAA NESDIS approach for inter-calibrating (or comparing) geostationary sensors with respect to a polar-orbiting sensor can be found in Gunshor et al. (2003). Radiances from both sensors with near nadir view of a scene containing mostly clear pixels, but also some cloudy skies, are averaged. Differences in mean scene radiances are corrected for spectral response differences through clear sky forward calculation. The corrected mean differences are attributed to calibration differences. Collocation in space and time (within thirty minutes) is required. Data are selected within 10 degrees from nadir for each instrument in order to minimize viewing angle differences. Measured means of brightness temperatures of similar spectral channels from the two sensors are compared.

In previous years, data collection was restricted to mostly clear scenes with mean radiances in the infrared window greater than 80 $mW/m^2/ster/cm^{-1}$, however this restriction has been lifted to allow for comparisons in cold, cloud-filled scenes. Data from each satellite are averaged to 100 km resolution to mitigate the effects of different Field of View (FOV) sizes and sampling densities (HIRS under-samples with a 17.4 km nadir FOV, AVHRR GAC achieves 4 km resolution by under-sampling within the FOV, GOES imager over-samples 4 km in the east-west direction by a factor of 1.7, and METEOSAT-5, METEOSAT-7, and GMS-5 have a nadir 5 km FOV). Mean radiances are computed within the study area. Clear sky forward calculations (using a global numerical model forecast for estimation of the atmospheric state) are performed to account for differences in the spectral response functions. The observed radiance difference minus the forward-calculated clear sky radiance difference is then attributed to calibration differences.

Results (Gunshor et al., 2003) suggest the infrared window sensors on GOES-8, GOES-10, MET-5, MET-7, and GMS-5 are within approximately 0.5 C of each other (and within 1.0 C of the NOAA-14 HIRS and AVHRR). The differences from the water vapor sensors are not as similar; GOES-8, -10 and GMS-5 are within 1.0 C of each other and within approximately 2.0 C of NOAA-14 HIRS while Meteosat-5 and Meteosat-7 are approximately equal and 4.0 C different from NOAA-14 HIRS.

Currently, NOAA-14, GOES-8, and GMS-5 are no longer operational. NOAA-15 and NOAA-16 are being used to intercalibrate the geostationary instruments. GOES-12 has replaced GOES-8 and GOES-9 has replaced GMS-5. Only a handful of case studies have been completed with MODIS, though currently efforts are being made to expand the use of MODIS on Terra to allow more frequent comparisons to the geostationary instruments. Until recently only the infrared window and water vapor channels have been compared and soon the 13.3µm band on GOES-12 will be compared to HIRS and MODIS. Also, tests are ongoing to evaluate the impact the global model estimation of atmospheric state has on the final results, specifically investigating the effect on the results of using a different global model.

Results are posted daily at *http://cimss.ssec.wisc.edu/goes/intercal/* with comparisons of GOES-10, GOES-12, GOES-9, Meteosat-5, and Meteosat-7 to NOAA-15 and NOAA-16 HIRS and AVHRR. Time series plots covering September 2001 through the current day show the results for each of the geostationary instruments compared to either polar orbiter with individual cases, a running average, a cumulative average, and the overall mean for the entire period displayed. The pre-publication draft of an article accepted in June of 2003 by the Journal of Atmospheric and Oceanic Technology can also be found there.

Gunshor, M. M., T. J. Schmit, and W. P. Menzel, 2003: Intercalibration of the infrared window and water vapor channels on operational geostationary environmental satellites using a single polar orbiting satellite. Accepted by the *Journal of Atmospheric and Oceanic Technology*.

**Polar Orbiter/Polar Orbiter Intercalibration**

Similar to the approach used for inter-calibrating GOES and POES sensors, a procedure is being developed at NOAA/NESDIS to inter-calibrate like radiometers on two different polar-orbiting satellites (Cao and Heidinger, 2002; Heidinger et al., 2002). This procedure utilizes simultaneous nadir observations from the two radiometers at orbital intersections, which only occur in polar regions. Simultaneous nadir overpasses between succeeding NOAA-series satellites (e.g., NOAA-15 and NOAA-16) occur approximately once every 8 to 9 days, providing ideal opportunities for inter-satellite calibration. The near-nadir observations by pairs of similar instruments on different satellites are collected in a few seconds. A pixel-by-pixel match of the data from the two satellites is performed, and scatter-plots and histograms are employed to compare the radiances. The average difference is also computed and time-trended. This method has been used for the immediate post-launch verification and long-term monitoring of infrared radiometers, as well as analysis of historical data to facilitate the construction of long-term time series.

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## 6.4. Climate Data, ISCCP and GPCP

The Climate Data Set (CDS) has been generated from Meteosat imagery since 1983. It contains a direct output of the so-called Scenes Analysis process. Hence, for all image segments of 32x32 IR pixels in size it contains information about all the scenes, both cloud and earth surface scenes, that have been identified within the segment. This data set, therefore, is potentially a valuable source of information for climate studies. It is available from the EUMETSAT data archive.

In support of the International Satellite Cloud Climatology Project (ISCCP) and the Global Precipitation Climatology Project (GPCP) of the World Climate Research Programme (WCRP) EUMETSAT has been providing data for the past decade.

For ISCCP, most of the geostationary weather satellite operators produce and delivery two reduced resolution versions of their imagery containing all spectral channels: after reducing the solar-wavelength channel resolution to match the infrared resolution (if necessary), the original images are sampled at 3-hr and 10-km intervals to produce the B1 product and at 3-hr and 30-km intervals to produce the B2 product. ISCCP then produces another version of the B2 data, called the B3 product that provides all geostationary (and polar) satellite imagery in a common format that can be accessed by one computer program.

The B3 product also provides complete pixel-by-pixel navigation (earth location plus illumination/viewing geometry) and a single absolute standard radiance calibration for the visible (0.6 micron) and window-infrared (11 micron) channels common to all spacecraft.

Thus, the ISCCP radiometric calibrations (available on-line at http://isccp.giss.nasa.gov and as a data product called BT data) provide a global standard for all weather satellites.

ISCCP also analyses the B3 product, together with operational sounder products and some other supplementary data, to produce a global cloud climatology reported as three products: the DX product is the same resolution as the original B3 data, the D1 product is still 3-hr time resolution but gridded to 280-km resolution, and the D2 product is the monthly-average of D1. All of these data products (B3, BT, DX, D1 and D2), which have been produced since July 1983, are available from the ISCCP Central Archives at NOAA/NCDC and from the NASA Langley Data Centre (DX is available only from the latter centre). Complete information and documentation can be found at the above-mentioned Web address.

For the GPCP a so-called High Resolution Precipitation Index (HPI) containing a description of the temporal and spatial variation of IR brightness temperature information in the tropical and sub-tropical regions are generated on a 1x1 degree grid and transmitted on a daily basis.

# 7. SATELLITE SOUNDINGS & SATELLITE DERIVED (TRACKED) WINDS

## 7.1. INTRODUCTION

CGMS has concentrated its efforts to enhance the utilisation and improve the quality of satellite products in mainly two areas:

- Satellite soundings
- Satellite derived winds

Under the auspices of CGMS two International Working Groups organise workshops on regular basis, at intervals of about 18 – 24 months, that facilitate exchange of recent progress in the science and utilisation of the products in these two areas.

The International TOVS Working Group has been meeting since 1983. There have been ten International TOVS Study Conferences that strengthen various temperature and moisture profile retrieval algorithms using TIROS Operational Vertical Sounder (TOVS) and foster more effective use of the polar-orbiting sounders especially in numerical weather prediction. Section 7.1 offers more details.

The CGMS Working Group on Cloud Motion Vectors has established a series of workshops that focus on the science and operational development and use of atmospheric motion vectors from geostationary satellites. This aspect is addressed in more detail in section 7.2. Other satellite products are also addressed at CGMS and are expected to become an increasingly important role once their operational utilisation gets closer; these are discussed in part in section 7.3.

## 7.2. SATELLITE SOUNDINGS

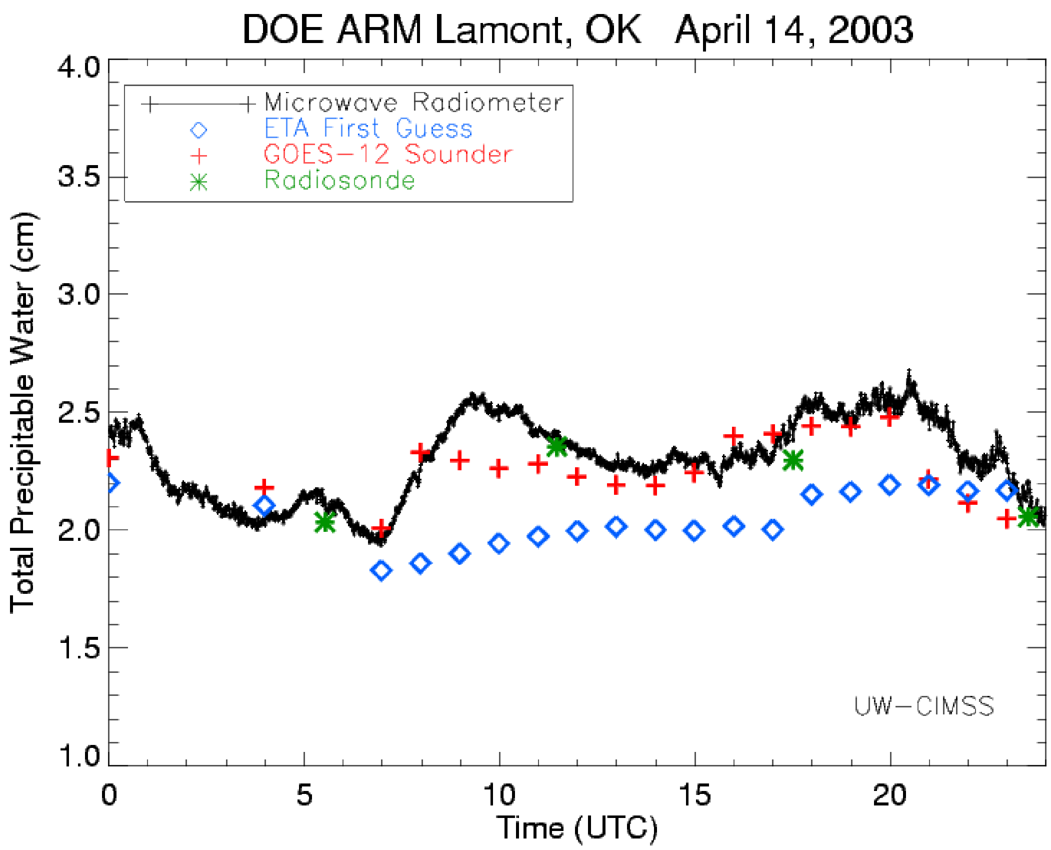
Satellite soundings and associated meteorological parameters have been the focus of the International TOVS Working Group (ITWG) where about 120 scientists from 25 countries participate in presentations and working group deliberations.

The ITWG is an ad hoc committee within the International Radiation Commission that was formed to (a) inter-compare and strengthen various temperature and moisture profile retrieval algorithms using TIROS Operational Vertical Sounder (TOVS) data, (b) foster expanded more effective use of the polar-orbiting sounders especially in numerical weather prediction, and (c) provide a forum for exchange of information and training materials regarding satellite remote sensing. The ITWG reports to the CGMS on their activities and responds to requests for action from CGMS.

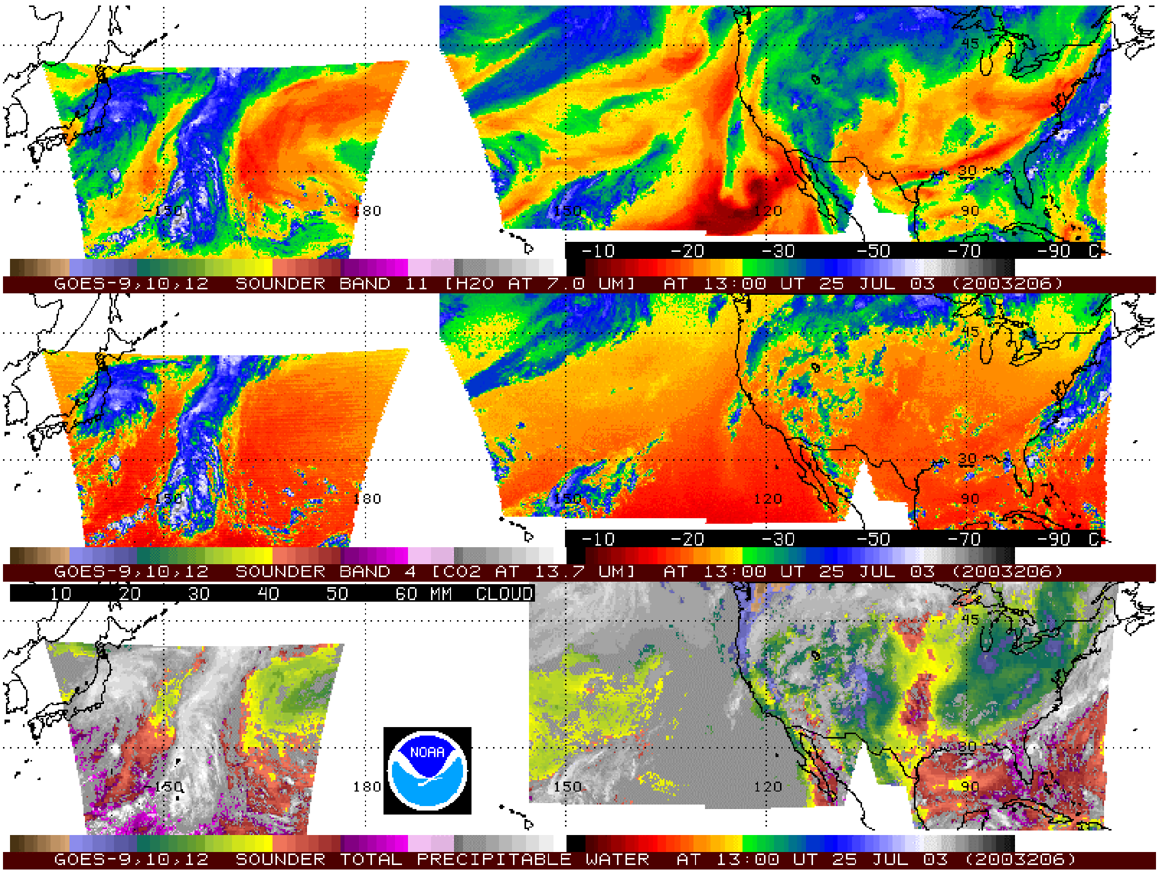
***Most recent ITWG meeting summary needed here***

### 7.2.1. Geostationary Satellite Soundings

Operational geostationary satellite soundings have been possible from the GOES Sounders since GOES-8. On April 1, 2003 GOES-12 replaced GOES-8 as the eastern satellite. GOES-8 gave almost nine years of operational service. Now the GOES-10 (western) and GOES-12 (eastern) sounders produce operational soundings every hour over North America and nearby oceans. Atmospheric temperature and moisture profiles are generated using a simultaneous physical retrieval algorithm. The total column water vapor RMS difference (square root of the sum of the bias squared and the standard deviation squared) with respect to radiosondes for the three month period (April-June) in 2003 was found to be reduced from 4.0 mm for the forecast first guess to 3.45 mm for the GOES-12 retrievals, roughly an improvement of 15%. It is found that GOES improves the layer mean values by between 0.1 and 0.4 mm in the three layers (approximately 1000-900hPa, 900-700hPa, and 700-300hPa). The sample size was 2605 matches**.** GOES-12 validation of total column water vapor also is being done at the DOE ARM CART near site Lamont, Oklahoma, USA. Comparisons between the moisture retrievals produced from the GOES-12 Sounder radiances and a Microwave Radiometer (MWR) show fair agreement (See Figure). GOES-12/10 hourly moisture information for the three separate layers detailed above, as well as the total column are being assimilated over the land in the Eta model for the regional forecasts. Parallel tests were run with retrieved products that showed no change in forecast quality when GOES-12 replaced GOES-8. GOES-12 sounder radiances are currently being tested for a fall implementation into the EDAS. As of July 8, 2003, the hourly cloud-top information from the Geostationary Operational Environmental Satellite (GOES) sounder data are being assimilated into the operational National Centers for Environmental Prediction (NCEP) Eta Data Assimilation System (EDAS). The regional Eta model joins the Rapid Update Cycle (RUC) model as two operational models assimilating GOES sounder cloud information to help improve the initial moisture and cloud fields. Soundings and Derived Product Images (DPI) continue to be made available (via NOAAPORT and other methods) to NWS Forecast Offices in real time, assisting them with their short term forecast responsibilities. Forecasters have found that the sounder profiles and DPIs are making significant positive impact to their forecasts of location and timing of severe weather (such as thunderstorms). Real-time examples of both retrieved moisture and stability information as well as cloud top pressures can be seen on the CIMSS web page at http://cimss.ssec.wisc.edu/goes/realtime/realtime.html. Another site with real-time GOES sounder products supported by the NOAA/NESDIS Forecast Products Development Team is at http://orbit-net.nesdis.noaa.gov/goes/. Following the replacement of GMS-5 with GOES-9 over the western Pacific (155 E) in May 2003, additional coverage in Sounder data and products are now available. These experimental products include Total Precipitable Water (TPW), cloud-top information, and displays of all GOES-9 Sounder bands. Realtime examples can be found at:
http://cimss.ssec.wisc.edu/goes/realtime/grtmain.html#gsall.




GOES-12 validations using a Microwave Radiometer (MWR) at the Department of Energy – Atmospheric Radiation Program (DOE ARM) Southern Great Plains (SGP) Cloud and Radiation Testbed (CART) site. Microwave radiometer (solid line), numerical model forecast (diamond symbols), and GOES-12 physical retrieval (plus symbols) of total precipitable water vapor comparisons near Lamont, Oklahoma on 14 April 2003. Radiosonde values (asterisk symbols) are also plotted.




GOES-9/10/12 Sounder Data and Products. In addition to the TPW DPI (bottom panel), two representative Sounder radiance images are also shown, with matching color enhancements, illustrating the difference between a water vapor (H2O) sensitive band and a carbon dioxide (CO2) sensitive band. Band 11 (top) at 7.0 um shows the moisture patterns (quite structured), while band 4 (middle) at 13.7 um shows the thermal pattern, both for the mid troposphere (in clear air).

## 7.3. SATELLITE DERIVED (TRACKED) WINDS

### 7.3.1. Working Group on Satellite Derived Winds

The CGMS Working Group on Satellite Derived Winds was set up at CGMS XXII as Working Group on Cloud Motion Winds (WG-CMW) to continue and emphasise the CGMS accomplishments and objectives in the area of operational extraction of Atmospheric (Cloud) Motion Vectors (Winds) (AMV) from satellite data. This includes coordination of complementary and compatible operational procedures, development of common verification and validation procedures, and encouragement of a robust programme of scientific research in this technology.

The objectives of the Working Group are:

(a) To devise and implement regular procedures for the exchange of data on inter-comparisons of operational AMV (*CMW)*;

(b) To promote harmonization and, where feasible/practical, the standardization of operational procedures for deriving AMV (*CMW)*;

(c) To establish agreement for standards in the verification and validation of AMV (*CMW)* derived from satellite data. This includes the:
- selection of data sources for validation, standardization of statistical parameters to be used for verification and inter-comparison,
- standardization of verification criteria, i.e., standard windows in space and time for collocations and standard criteria for the acceptance (or consideration) of the validation data.

(d) To promote increased scientific activity in this field, and to establish routine means of exchanging scientific results and progress;

(e) To establish and encourage a regular dialogue and information exchange with the users of the data. This should include both scientific and operational exchanges in order to:
- agree on the designation of data quality as a part of the delivery of the data (e.g., quality flags),
- agree on modifications to data formats and codes, and
- discuss means of verifying the usefulness and quality of the data for numerical analysis and prediction.

(f) To make recommendations to national and international agencies regarding the utilization of current and the development of future satellite instruments on both polar and geostationary satellites.

The Working Group on Satellite Derived Winds organises workshops, co-sponsored by CGMS members. The Workshops promote the exchange of scientific and operational information between the producers of CMW, the research community, and the user community.

### 7.3.2. Utilisation of Atmospheric Motion Vectors (AMVs)

Global observations of atmospheric wind fields are potentially the most important data in the analysis for numerical weather prediction. Direct observations of wind fields are indispensable at low latitudes where winds cannot be inferred from the mass field. Wind observations from satellites also constitute the sole source of wind data over wide regions of the Southern Hemisphere. Very good progress has been made over the last fifteen years in the derivation of winds (or atmospheric motion vectors: AMVs) at satellite operating centres and, on the user side, at numerical weather prediction centres in their capability to assimilate the wind information into numerical forecast models. Nowadays AMVs are a well-established and important ingredient in the global observing system.

CGMS has played the key role in fostering a continuous improvement in the winds product and its utilisation. This progress has largely between achieved through the working groups that are part of the regular CGMS meetings.

### 7.3.3. International Winds Workshop

The establishment of the International Winds Workshops (IWW), with the first the workshop held in 1991 in Washington D.C., initiated a close cooperation between satellite operators, users at NWP centres and the science community.

Six IWWs have been held since then: the second in Tokyo, Japan in1993, the third in Ascona, Switzerland in 1996, the fourth in Saanenmöser, Switzerland in 1998, the fifth in Lorne, Australia in 2000 and the sixth in Wisconsin, USA in 2002. The fruitful outcome of these workshops is published as workshop proceedings by EUMETSAT. An effort is also made to communicate the workshop results succinctly to the open science community through publication of a workshop report in a peer-reviewed journal (Schmetz et al., 1997 and 1999).

The specific accomplishments of the most recent IWW were: ***brief summary needed here***

The reports of all of the IWWs are available on the EUMETSAT web site: www.eumetsat.de.

### 7.3.4. Wind Extraction Methods

#### 7.3.4.1. EUMETSAT

The input to the meteorological products extraction process is a geometrically corrected (rectified) image, which is received by the MPEF and processed to produce the meteorological products. The full earth disc image is divided into sub-areas of 32x32 pixels (so-called 'segments'), giving a ground resolution of 160 km at the sub-satellite point. Thereby the Meteosat area (including space) is covered by an 80x80 segment matrix. Each segment is at a fixed geographical position. In addition only those image segments are exploited for product generation, which fall into the area of 60 degrees around the sub-satellite point (SSP). Therefore, a total of 3848 segments are available for product extraction.

The **Cloud Motion Winds (CMW)** product is generated by applying a correlation algorithm to sequences of three images (VIS in half resolution). By tracking the movement of cloud fields, winds can be extracted. The winds are derived for all three spectral channels as the Intermediate CMW Product, and an AQC Quality Index (QI) is assigned to every wind. However, the final CMW product only includes winds with a QI greater than a threshold value, only the best wind for each segment determined from the QI value, and there are also another limitations specified here. A typical product will contain up to 750 winds per channel. The product is distributed for the synoptic hours of 00, 06, 12 and 18 UTC in SATOB code.

The **Expanded Low-resolution Winds (ELW)** product is generated from the same Intermediate CMW Product (see above), and consists of all winds from all channels with a QI greater than an AQC threshold considerably lower than the AQC threshold for the CMW product. The ELW product is generated every 1.5 hours and distributed in BUFR code, and contains typically about 4000 winds.

The **High Resolution Visible Winds (HRV)** product is generated using essentially the same algorithm as the CMW product, but applied to the VIS images in full resolution. AQC is applied, and a typical product will contain up to 2000 winds. The product is generated for the synoptic hours of 06, 09, 12, 15 and 18 UTC and distributed in BUFR code.

The **Clear-Sky Water Vapour Wind (WVW)** product is generated using essentially the same algorithm as the other wind products, but tracking structures in the WV image from non-cloudy areas. AQC is applied, and a typical product will contain about 500 winds. The product is generated every 1.5 hours, and distributed in BUFR.

The **High Resolution Water Vapour Wind (HWW)** product is generated using essentially the same algorithm as the CMW product, but the WV images are divided into sub-areas of 16x16 pixels, i.e. the same resolution as the HRV product. Only segments where a cloud has been detected are processed. AQC is applied and the product is generated every 1.5 hours, and distributed in BUFR. Further details can be found at the EUMETSAT Website http://www.eumetsat.de.

### 7.3.4.2. Japan

Cloud Motion Winds (CMW) are derived from the displacement of Cirrus for high level CMWs and cumulus for low level CMWs over three images at 30-minute intervals. Extraction of CMW is carried out with automatic and manual processes. In the automatic process two stages of targeting and tracking of clouds are carried out. In the manual process they are carried out in a man-machine interactive environment. In both cases wind derivation and height assignment are carried out automatically. Derived winds go through both automatic and manual quality control. Water Vapour motion Winds (WVMW) are extracted by a similar but fully automatic process.

In the automatic process, targeting and tracking are carried out as follows:

Candidate points for potential targets are grid points with 1 degree intervals of latitude and longitude from 50N to 49S and 90E to 171W. Histogram analysis for selecting target cloud is performed for an area of 32 by 32 pixels centred at a candidate point in the middle infrared image of the series of three images. For the points (areas) which pass the analysis, tracking is carried out. The displacement of a selected cloud is calculated by pattern matching by using a cross-correlation technique with visible images (low level CMW) and infrared images (high level and low level CMW at nighttime).

In the manual process, targeting and tracking are carried out by visualising sequences of image loops on a display.

The positions of the tracked clouds are transformed into latitude and longitude and wind speeds and directions are calculated.

The height of the low level CMW is fixed at 850hPa. The height of the high level CMW is assigned to be the cloud top height derived from its brightness temperature. The height of semi-transparent Cirrus cloud is corrected by using IR and WV channel data. During manual quality control the heights of high level CMW are also checked and corrected manually if necessary. The heights of WVMW are assigned by using the coldest brightness temperature in target areas.

Wind data passing automatic and manual quality control are operationally disseminated to JMA headquarters and the GTS.

### 7.3.4.3. USA

Operational winds from GOES are derived from a sequence of three navigated and Earth located images. The current operational wind products being generated at NOAA/NESDIS are shown in Table 7.3.4.3. The frequency at which each product is produced, together with the GOES image sector used, and image interval is presented in this table.

| *Wind Product* | *Frequency (Hours)* | *Image Sector(s)* | *Image Interval (minutes)* |
|---|---|---|---|
| ***IR Cloud-drift*** | 3 | RISOP | 7.5 |
| | 3 | CONUS | 15 |
| | 3 | Extended NH: SH | 30 |
| ***Water Vapor*** | 3 | Extended NH; SH | 30 |
| ***Vis Cloud-drift*** | 3 | RISOP | 7.5 |
| | 3 | PACU/CONUS | 15 |
| | 3 | Extended NH; SH | 30 |
| ***Sounder WV (7.4um)*** | 3,6 | CONUS/Tropical | 60 |
| ***Sounder WV (7.0um)*** | 3,6 | CONUS/Tropical | 60 |

**Table 7.3.4.3. NOAA/NESDIS Operational Satellite Wind Products**

The winds are calculated by a three-step objective procedure. The initial step selects targets from the middle image of the image triplet, the second step assigns pressure altitude, and the third step derives motion. Tracers are assigned heights based on a temperature/pressure derived from radiative transfer calculations in the environment of the target. Motion is derived by a pattern recognition algorithm that matches a feature within the "target area" in one image within a "search area" in the second image. For each target two winds are produced; one computed forward in time and the other computed backward in time. These two winds are then averaged to arrive at the wind vector for this target. An objective editing scheme is then employed to perform quality control: the first guess motion, the consistency of the two winds, the precision of the cloud height assignment, and the vector fit to an analysis are all used to assign a quality flag to the "vector" (which is actually the average of the two vectors). Two more quality flags are assigned to the satellite derived wind vector. These quality flags are based upon the EUMETSAT quality control scheme (Holmlund et al., 2000) and are computed with and without model forecast wind data.

All of the operational NESDIS wind products shown in Table 1 are encoded into Binary Universal Form for the Representation (BUFR) of meteorological data. All of the products, with the exception of the sounder water vapor winds, are encoded into the SATOB format and distributed over the Global Telecommunication System (GTS). NESDIS has updated its operational GOES satellite wind BUFR encoder to correct deficiencies noted by users of these data. A summary of changes made to the BUFR encoder include:

Replacing local descriptors with WMO-sanctioned descriptors

Using the latest version of the BUFR Tables

Assuring that the quality control section contains Class 33 entries only

Generating one BUFR message per file and increase the number of satellite wind observations per BUFR message. This eliminates file segmentation problems encountered by users, particularly when processing larger NESDIS wind files.

Using newly defined WMO headers for GTS distribution

In addition to transmitting the GOES wind products over the GTS, NESDIS will also be transmitting these products to the NOAA/National Weather Service's (NWS) Advanced Weather Interactive Processing System (AWIPS). This represents a significant milestone for NOAA, as this is the first time these products will be distributed via an operationally supported network to NWS field forecast offices. Once at the NWS field forecast offices, weather forecasters will be able to use existing AWIPS graphics capabilities to easily integrate these products with other data sources (model output, rawinsondes, aircraft reports) which, ultimately, will help them prepare improved weather forecasts.

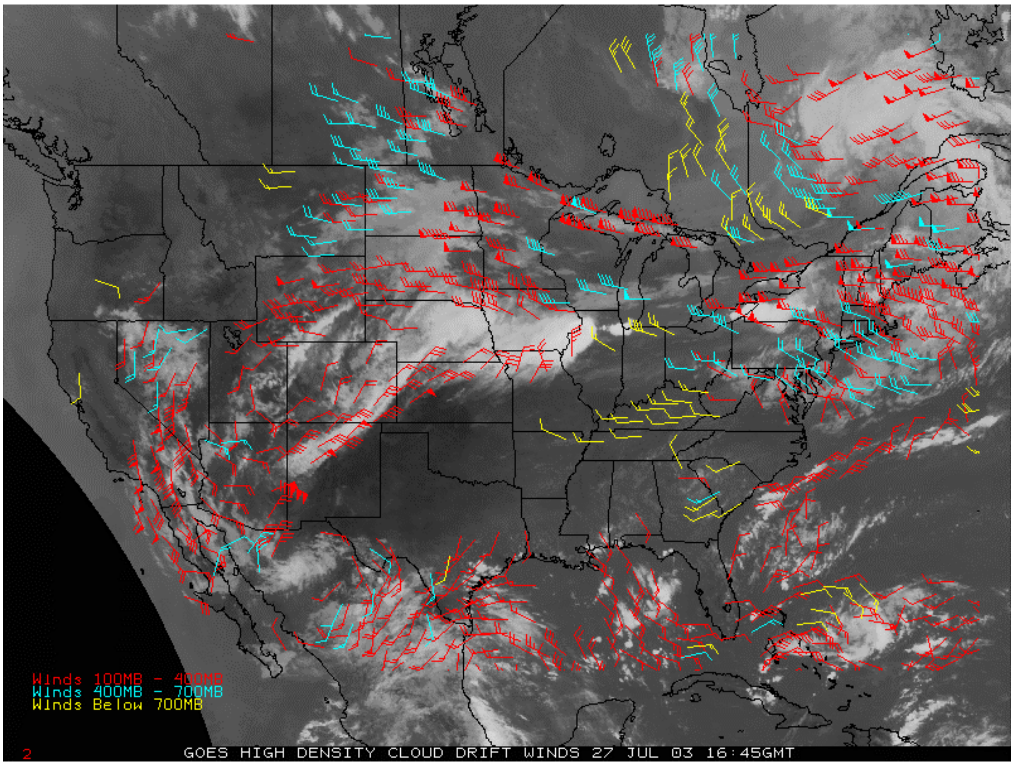



Figure 1. GOES-12 infrared cloud-drift wind product over the CONtinental United

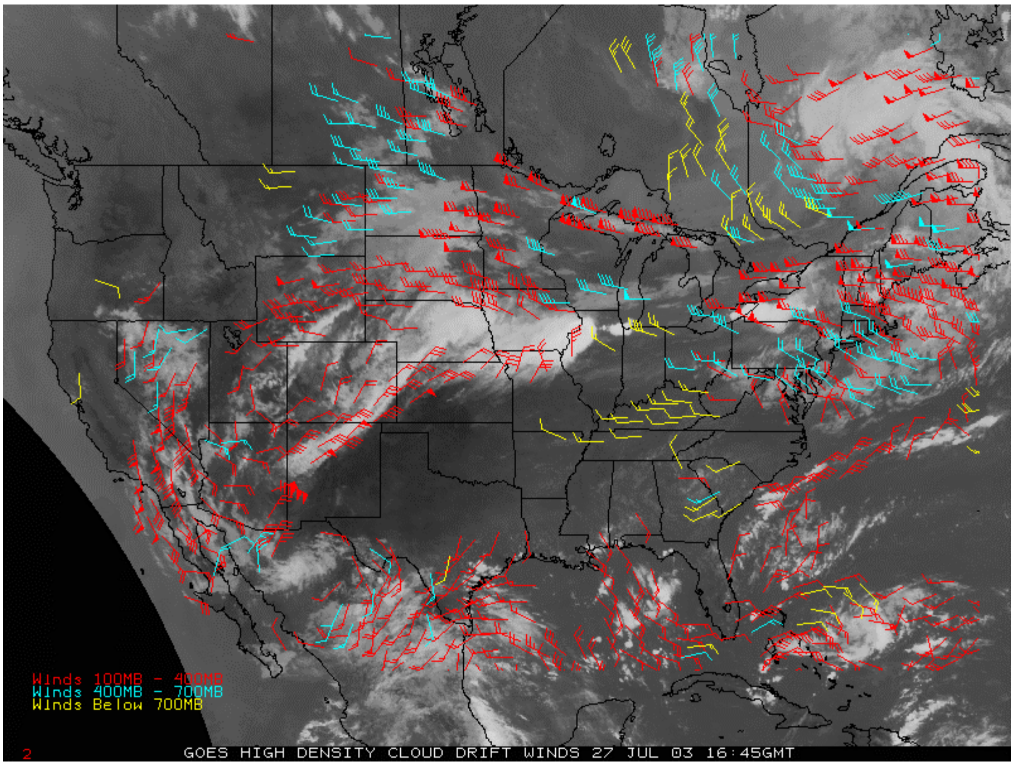



Figure 1. GOES-12 infrared cloud-drift wind product over the CONtinental United States (CONUS) at 16:45 UTC on July 27, 2003.

On April 1, 2003 GOES-12 replaced GOES-8 as the eastern satellite. The changes made to the GOES-12 imager offered benefits to the derivation of cloud-drift and water vapor motion winds. First, the addition of the 13.3um channel allowed, for the first time since GOES-7, cloud tracer height assignment to be accomplished with the well-known CO2-ratioing algorithm (Menzel, *et al*., 1983). Testing and validation of the GOES-12 wind products during the NOAA GOES-12 Science Test showed that the highest quality (as compared to collocated rawinsondes) high-level cloud-drift winds were those assigned CO2 heights. Based on this result, the height selection process was modified to follow a pre-determined order. For each tracer, a CO2 height is selected first (if available), then the H2O-intercept height (if the CO2 height is not available), and then the window height (if neither the CO2 height or H2O-intercept height is available). Second, the improved resolution (8km to 4km) of the water vapor channel has improved the water vapor motion wind product through improved tracking of water vapor features.

Steady improvements in the GOES cloud-drift wind algorithms, processing schemes, and quality control algorithms continue to be made. This is clearly evident in Figures 2 and 3, which illustrate the time series of mean vector difference and speed bias statistics between collocated GOES-E high level (100-400mb) cloud-drift winds and radiosonde winds in the Northern Hemisphere Extra-tropics (25N-90N) and the tropics (25N-25S) for the period May 6, 1998 to July 30, 2003. Note the steady reduction in mean vector difference over this time period.

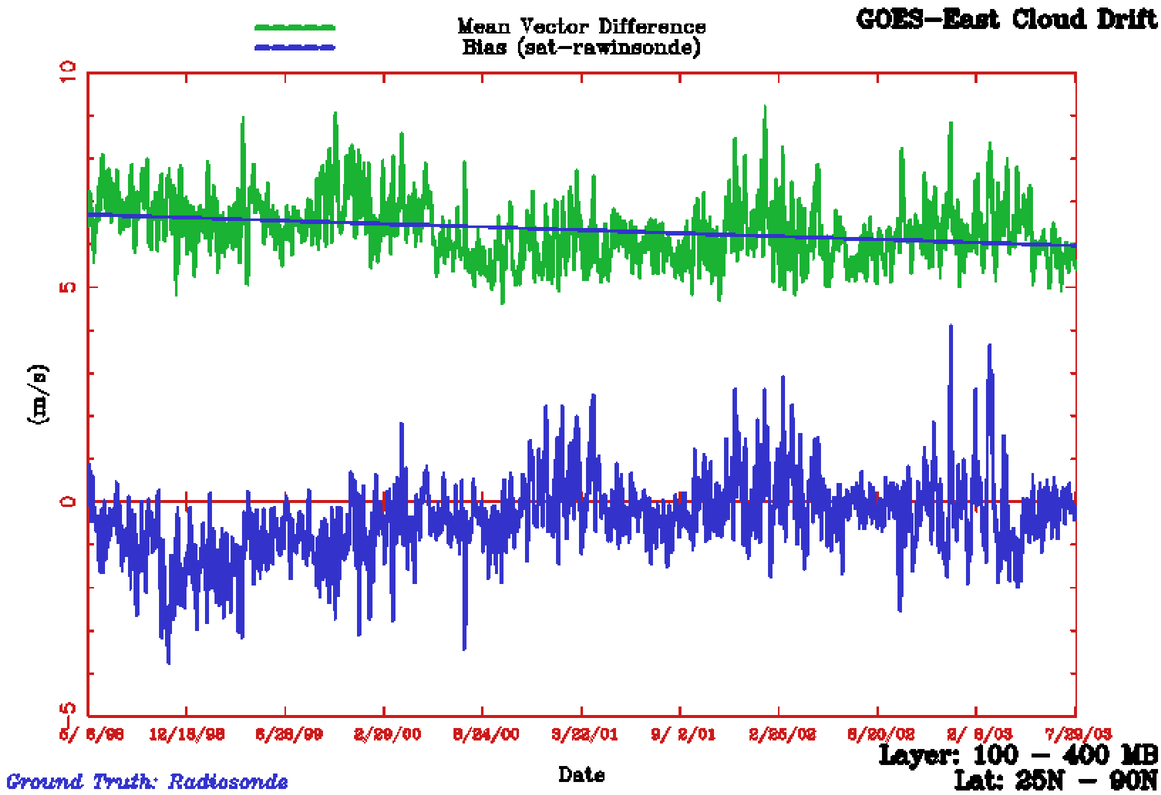



**Figure 2**. Time series (5/6/1998 – 7/29/2003) of the mean vector difference and speed bias between high level (100-400mb) GOES-E infrared cloud-drift winds and collocated radiosondes in the tropics.

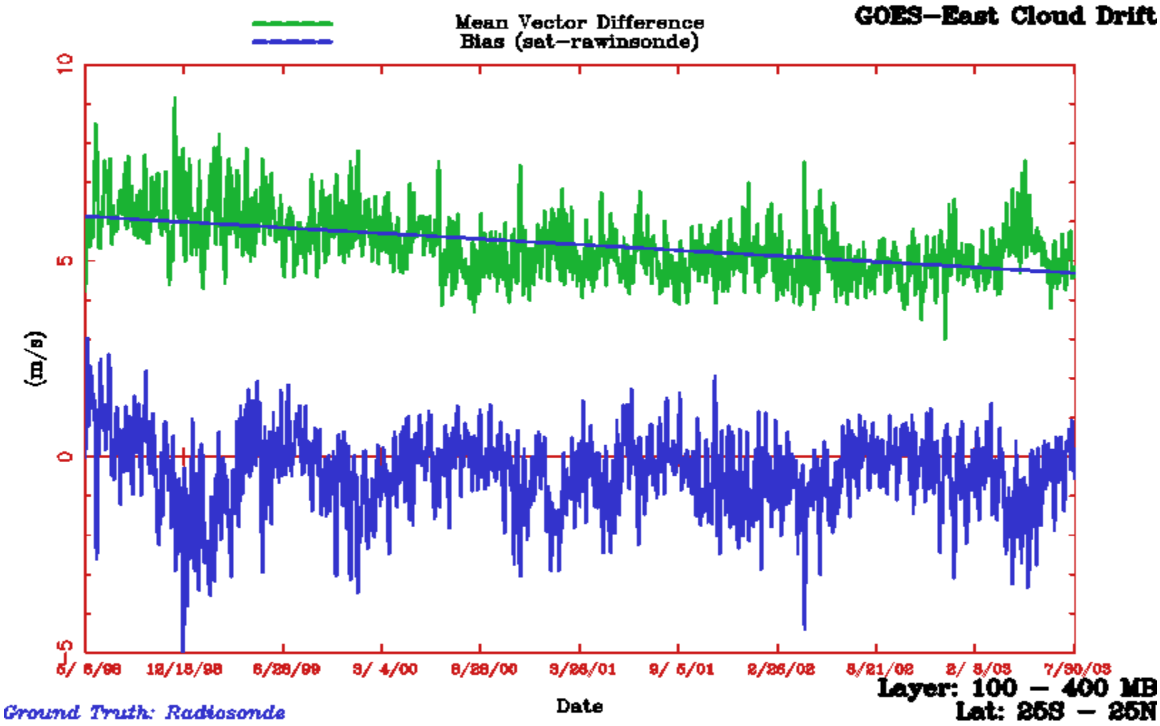



**Figure 3.** Time series (5/6/1998 – 7/29/2003) of the mean vector difference and speed bias between high level (100-400mb) GOES-E infrared cloud-drift winds and collocated radiosondes in the tropics.

On May 22, 2003, GOES-9 officially replaced Japan's ailing Geostationary Meteorological Satellite-5 (GMS-5), per a formal agreement between the United States and Japan. NESDIS began routine production of cloud-drift winds and water vapor motion winds every 6 hours from GOES-9. These are made available on a NOAA/NESDIS anonymous ftp server (gp12.wwb.noaa.gov) in BUFR format. The datasets can be found in /pub/bufrwinds/ where the dataset naming conventions are satwnd.bufrcdft.goesP* and satwnd.bufrwvap.goesP* for the cloud-drift winds and water vapor motion winds, respectively.

NESDIS is currently transitioning the capability (Santek et al., 2003) to routinely generate cloud-drift winds and water vapor motion winds in the polar regions from the Moderate Resolution Imaging Spectroradiometer (MODIS) instruments onboard NASA's Aqua and Terra polar orbiting satellites. Cloud and water vapor tracking with MODIS data is based upon the established procedures used for GOES that are described in Nieman et al., 1997. Figure 4 shows a 12-hour composite of cloud-drift winds from Terra on March 5, 2001 Model impact studies at NASA's Data Assimilation Office (DAO) and the European Center for Medium Range Weather Forecasting (ECMWF) have demonstrated that numerical weather prediction (NWP) model forecasts for the Northern Hemisphere are improved when the MODIS polar winds are assimilated. NESDIS plans on including the MODIS winds in its operational satellite wind production suite in late 2004.

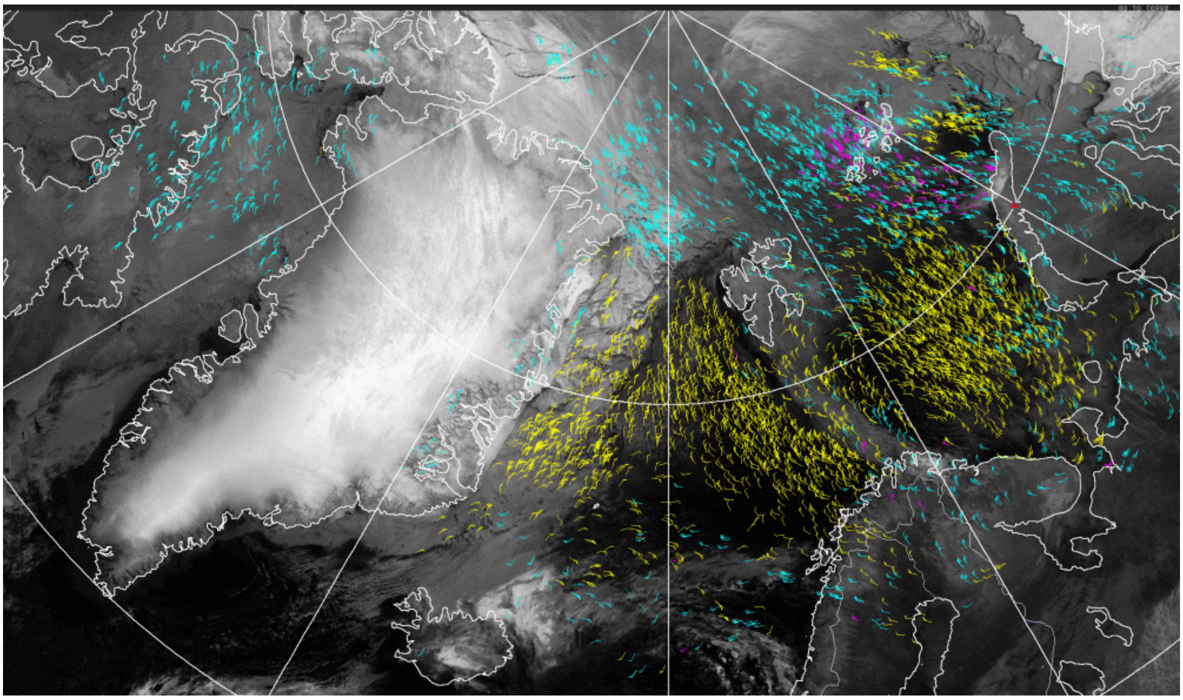



**Figure 4.** Daily composite of 11um MODIS imagery over half of the Arctic region. The infrared cloud-drift winds were derived over a period of 12 hours. There are about 4500 vectors in the image.

**References:**

Holmlund, K., C.S. Velden, and M. Rohn, 2000: Improved quality estimates of atmospheric motion vectors utilizing the EUMETSAT quality indicators and the UW/CIMSS auto-editor. *Proc. Fifth Int. Winds Workshop*, Lorne, Australia, EUMETSAT, 73-80.

Menzel, W.P., W.L. Smith, and T.R. Stewart, 1983: Improved cloud motion wind vector and altitude assignment using VAS. *J. Clim. and Appl. Meteor*, **22**, 377-384.

Nieman, S., W.P. Menzel, C.M. Hayden, D. Gray, S. Wanzong, C. Velden, and J. Daniels, 1997: Fully automated cloud-drift winds in NESDIS operations. *Bull. Amer. Meteor. Soc.*, 78(6), 1121-1133.

Santek, D., J. Key, C. Velden, 2003: Real-time derivation of cloud-drift and water vapor motion winds in the polar region from MODIS data. *Proc. 12th Conf on Satellite Meteorology and Oceanography*, 9-13 February 2003, Long Beach, CA.

### 7.3.5. International Comparison of Satellite Winds

As one of the early joint activities of CGMS it was agreed to perform on a regular basis intercomparisons of satellite tracked winds in order to assess the homogeneity and accuracy of this product. Two forms of comparison had been proposed and accepted originally:

- direct intercomparison between satellite winds in the areas of overlap between adjacent satellites,
- intercomparison with conventional data

CGMS X agreed to continue the international comparison program with the following modifications:

- biased Rawinsonde reports would be eliminated by analysing Rawin stations to identify those with persistent errors and omitting those reports from the comparison programme,
- the "collocation box" would be refined. This could be done by using an elliptical collocation area whose major axis was oriented along the wind direction and whose length was proportional to the wind speed. Sharply reducing the length of the minor axis would minimise the comparison on winds that lay on opposite sides of shear lines and remove statistical differences, which were real-time space variations.

CGMS then agreed on the collocation ellipse parameters presented in the following table.

**Table 7.3.5 Collocation ellipse parameters agreed by CGMS**

| Wind Speed | Major Axis | Minor Axis |
|---|---|---|
| **High & medium level winds** | | |
| less than 10 m/s | 225 km | 175 km |
| from 10 to 25 m/s | 250 km | 160 km |
| Greater than 25 m/s | 300 km | 100 km |
| **Low level winds** | | |
| any speed | 225 km | 175 km |

At CGMS XII, ESA pointed out that they were continuing to use latitude-longitude collocation boxes for the comparison of Meteosat satellite winds and rawinsonde data. Several tests had been carried out using the elliptical collocation area as recommended at CGMS XI. However, the number of comparisons thus obtained was considered to be too few to have any statistical significance.

At the CGMS XXIII the Working Group on Satellite Tracked Winds recommended that evaluation of operational wind production quality should be accomplished with a new standardised reporting method. They recommended three parts to the report. (1) Monthly means of speed bias and rms vector difference between radiosondes and satellite winds for low- (> 700 hPa), medium- (700-400 hPa), and high- (< 400 hPa) levels together with the radiosonde mean wind speed. This should be done for three latitude bands: north of 20 N, the tropical belt (20N to 20S), and south of 20 S. (2) Trends of the evaluation statistics for the monthly cloud motion vectors and water vapour motion vectors through the last 12 months. (3) Information on recent significant changes in the wind retrieval algorithm. This reporting has now been established as routine.

The exact reporting format had been proposed at IWW3 in 1996 and the relevant subsection from the Report of the Working Group on Verification is reproduced below:

“The WG started with a discussion of an appropriate reporting format for the comparison of Cloud Motion Vectors (CMV) with radiosonde data. The goal of the reporting is to assist in achieving international production of like quality motion vectors. It was noted that the working paper submitted by the US at CGMS 24 was a good starting point. The WG suggested reporting MVD, RMSE, BIAS, SPD, NCMV, and NC for low (>700 hPa), medium (700 to 400 hPa), and high (<400 hPa) levels for all winds as well as those segmented by latitude bands in the northern extra-tropical regions (north of 20N), tropics (20N to 20S), and southern extra-tropical regions (south of 20S). Some definitions follow for clarification:

The mean vector difference (MVD) is given by,

$$(MVD) = \frac{1}{N}\sum_{i=1}^{N}(VD)_i .$$

where the vector difference $(VD)_i$ between an individual CMV report (i) and the collocated rawinsonde (r) report used for verification is,

$$(VD)_i = \sqrt{\left(U_i - U_r\right)^2 + \left(V_i - V_r\right)^2} .$$

The root-mean-square error (RMSE) traditionally reported is the square root of the sum of the squares of the mean vector difference and the standard deviation about the mean vector difference,

$$(RMSE) = \sqrt{\left(MVD\right)^2 + \left(SD\right)^2} .$$

where the standard deviation (SD) about the mean vector difference is,

$$(SD) = \sqrt{\frac{1}{N}\sum_{i=1}^{N}\left(\left(VD_i\right) - \left(MVD\right)\right)^2} .$$

The speed bias (BIAS) is given by

$$(BIAS)_i = \frac{1}{N}\sum_{i=1}^{N}\left(\sqrt{U_i^2 + V_i^2} - \sqrt{U_r^2 + V_r^2}\right)$$

The number of wind vectors produced is given by NCMV and the number of collocations found with Raobs is indicated by NC. Collocation with radiosondes should be within 150 km.

**Table 7.3.5.1 Example of a reporting template**

| | ALL REGIONS | NH EX-TROP | TROP | SH EX-TROP |
|---|---|---|---|---|
| ALL LEVELS<br><br>MVD<br>RMSE<br>BIAS<br>SPD<br>NCMV<br>NC | | | | |
| HI<br><br>MVD<br>RMSE<br>BIAS<br>SPD<br>NCMV<br>NC | | | | |
| MID<br><br>MVD<br>RMSE<br>BIAS<br>SPD<br>NCMV<br>NC | | | | |
| LOW<br><br>MVD<br>RMSE<br>BIAS<br>SPD<br>NCMV<br>NC | | | | |

This reporting should be done for cloud motion vectors (CMV) derived from infrared window images (CMV), water vapour motion vectors (WVMV) derived from water vapor images (indicating whether only gradients in cloudy regions were tracked or both cloudy and clear; separation of cloudy and clear statistics is desirable, if possible), motion vectors derived from visible images (VISMV), and the total combined wind field (TOTMV). Statistics should be reported for three month segments (Dec to Feb, Mar to May, Jun to Aug, and Sep to Nov) and should be submitted the month after the segment is finished.

In addition, a plot of the monthly MVD and BIAS of the full disk winds for each wind type category for the last twelve months also should be submitted to assist in indicating trends. A history of processing changes should also be appended.

It is recognised that existing trend analysis produced locally at different operational wind production centres may be based on different collocation requirements or statistical parameters; maintaining these will require some additional effort at each site."

The issue of the adequate colocation box for comparison of AMVs with radiosondes has been addressed at IWW4. A study was performed by JMA (Tokuno, 1998) investigating the differences in colocation statistics between the elliptical colocation areas proposed earlier and a circular one. JMA noted that differences exist with regard to RMS vector difference but no difference was discerned for the bias.

The relevant discussion at IWW4 should put at rest the continuing arguments for elliptical areas. It is suggested that satellite operators continue their well-established colocation statistics in order to maintain a consistent monitoring. It is also noted that the data monitoring performed at NWP centre provides a unified database for quality monitoring of AMVs (c.f. statistics from NWP SAF on web page). However, as note of caution it is added that NWP monitoring also has caveats which potentially distort the statistics (e.g. positive feedback in terms data quality when data are used and little other data are available or to the contrary, too low a weight to AMVs in comparison to other wind data and the first guess, which might not be correct).

**Reference:**

Tokuno, M., 1998: Colocation area for comparison of satellite winds and radiosondes. Proceedings of the 4th International Winds Workshop, Saanenmöser, Switzerland, 20 – 23 October 1998, EUM P 24, p. 21 – 28.

## 7.4. OTHER METEOROLOGICAL PARAMETERS

### 7.4.1. EUMETSAT

To enhance the use of satellite data over land, a Meteosat Second Generation (MSG) Biosphere Working Group (MBWG) had been established jointly with the Joint Research Centre of the European Commission in order to analyse requirements and the potential of MSG to contribute to the observation of relevant geophysical quantities. A successful series of workshops of the MBWG was concluded with a report summarising requirements, potential and specific recommendations that should ensure the success of MSG land applications. Efforts toward improved use of infrared soundings are being undertaken by a working group of the International IASI Sounder Science Working Group (ISSWG).

A prototype algorithm for the cloud masking and cloud products from MSG has been presented. It is based on threshold techniques and holds promise for utilisation as a pre-processor for day-2 products from MSG. The algorithm is very flexible and can also be utilised when channels are missing. Examples from applications to Meteosat and the GOES-8 imager and sounder are available in an EUMETSAT technical memorandum, which can be downloaded from http://www.eumetsat.de.

### 7.4.2. Japan

MSC has been working on various aspects of improved digital processing of satellite data. One initiative is digital signal processing technique that presents the over-sampled MTSAT data (by a factor of 1.75) at 2-km resolution in image format. Initial research results are impressive and considerations for operational implementation are being investigated.

MSC has also presented an approach to generate satellite cloud grid information data. Using infrared window and water vapour channel data to detect clouds in a threshold technique, cloud amount, height, and type are processed at 0.2 latitude and 0.25 longitude resolution. Temporal consistency cloud checks are being looked into as a useful addition.

### 7.4.3. PRC

FY-1 C image products, land products, ocean products and atmosphere products have been generated. Image products play a great role in disaster monitoring, such as forest fire, flooding, blizzards etc; they include stretched gridded images, special event images, orbital images, image mosaics in regional and globe size and products images. Land products are used to monitor the variation of land cover and environment changes, such as using vegetation index to monitor the crop growing condition over China, using snow cover data in snow disaster monitoring and in research of climate changes. The FY-1C system provides many products over land in both regional and global scale. For ocean products, FY 1C satellite has 1 short wave IR channel, 2 long wave IR channels and 3 ocean colour observation channels. These data can be used to produce many products such as sea surface temperature, sea ice, and ocean colour and so on. FY-1C atmosphere products include cloud parameters, outgoing long wave radiation (OLR), and water vapour total content. These products are being used for weather analysis and climatological research.

### 7.4.4. Russia

Global geostationary products are being processed by SRC Planeta from Meteosat -7, -5, GMS-5, GOES-W, and -E. Several examples of the global cloud mosaic product were presented at CGMS XXVII and XXVIII, and can be found on SRC Planeta Internet server http://planet.iitp.ru. [Note: this is newly developed thematic server containing samples of products and some application projects. Currently it is in Russian language; English conversion is planned in the near future].

# 8. ARCHIVE AND RETRIEVAL OF DATA

## 8.1. INTRODUCTION

The most obvious characteristic of data flowing from geostationary satellites is its immense data volume, which presents formidable archiving problems. There are two distinct categories of data, namely, image data and products derived from image data (e.g. wind vectors, SST, etc.). Most archive systems also store data collected via satellites from DCP.

The vast quantity of image data poses severe storage problems if it has to be archived in digital form. CGMS urges satellite operators to archive as much data as possible, but in general the problem is such that the form and extent of each archive has been dictated largely by local interests rather than by any agreement within CGMS.

Whilst a full photographic archive and as much digital data storage as feasible was recommended in the past, there is now a movement towards comprehensive digital archives as storage technology develops. Furthermore, a measure of standardisation of data formats on archive storage media has been achieved by CGMS.

The problems of archiving image derived products (wind vectors, sea surface temperatures, etc.) are less severe and satellite operators normally archive all of these data in digital form. Indeed, WMO stresses the need to have products permanently stored in a form suitable for easy computer access.

## 8.2. ARCHIVE SYSTEM OPERATED BY CGMS MEMBERS

### 8.2.1. EUMETSAT

The Meteorological Archive & Retrieval Facility (MARF) is an integrated part of the Ground Segment of the Meteosat Transition Programme (MTP). It has been in operations since November of 1995 when EUMETSAT took over Meteosat operations from ESOC. At that time the entire physical archive of Meteosat digital image data and derived products was transferred to EUMETSAT and the process began of transcribing these data from ca. 45,000 magnetic tapes and cartridges on to new media. Thus the MARF is the sole repository for all Meteosat image data and derived products.

The archive medium originally selected for the MARF was the optical disk (Write Once Read Many (WORM) technology). These disks had a capacity of 6.55 GBytes and were accessed via a robotic unit with a capacity of 67 disks. With software compression employed this meant an overall near-line capacity of some months of image data.

However, advances in technology prompted the decision to change the archive medium to DLT (Digital Linear Tape) in 1999. DLTs have a native capacity of 35 GBytes and with hardware compression this is increased to around 90 GBytes. The migration of the entire archive contents to this new medium was completed in just over six months. The DLTs are accessed via a robotic Tape Library Unit with a capacity of 500 tapes giving a near-line capacity of many years of image data.

With the start of MSG routine operations in November 2003 the MARF will be replaced by the new Unified Meteorological Archive & Retrieval Facility (U-MARF). This will then become the single repository for all image data and products including historic data (going back to Meteosat-1 in 1978) and future data from the operational lifetime of both the MSG and EPS satellites series. The U-MARF will feature AIT/2 physical media and greatly enhanced user capabilities including a comprehensive on-line (web-based) external user interface.

The retrieval and delivery service currently offered by the MARF (and considerably enhanced by the U-MARF) includes a wide range of delivery media and formats. Users have the possibility to request data with almost any combination of temporal, geographical and spectral characteristics. Only practical considerations limit what can be supplied (e.g. order volumes are constrained to limit unmanageable load on human resources). Increasingly the use of the Internet for fast on-line deliveries is becoming more and more popular. Whilst present bandwidth of publicly available systems is a limiting factor, technology is advancing at a tremendous rate and this will decrease as a limiting factor in the foreseeable future. In addition to digital and graphical formats, images may be delivered as high quality prints for qualitative applications.

### 8.2.2. India

The INSAT satellite imagery data, related information and the derived products such as CMVs are archived on CCTs only. An Archived product is stored as a collection of files on magnetic tape in VAX/VMS Files-11 format. The length of CCTs is generally 2400 ft and recording density is either 1600 or 6250 BPI. The archival system is under Up-gradation and data recording on CCT will shortly be updated by new technology. The general tape format for data is:

BEGINNING OF TAPE MARK

| |
|---|
| VOLUME LABEL |
| HEADER 1 LABEL |
| HEADER 2 LABEL |
| HEADER 3 LABEL |
| HEADER 4 LABEL |

describe and delimit file

optional

/(END OF FILE MARK) separates the various tape sections

| |
|---|
| DATA RECORD 1 |

data section

1 file .

| |
|---|
| DATA RECORD N |

/(END OF FILE MARK)

| |
|---|
| END OF FILE LABEL 1 |
| END OF FILE LABEL 2 |
| END OF FILE LABEL 3 |
| END OF FILE LABEL 4 |

correspond to header labels,

describe and delimit file
/( END OF FILE LABEL)

END OF TAPE MARK

### 8.2.3. Japan

JMA has routinely carried out data archiving. The data produced at Meteorological Satellite Center (MSC) are archived in the following forms:

- Picture data: Original negative film, Microfilm, VTR tape
- Digital data in MT/CMT: Original VISSR image, Extracted meteorological parameters (Cloud motion wind, Sea surface temperature etc.)
- Contour chart

The Monthly Report of the Meteorological Satellite Centre 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 the table below.

**Table 8.2.3 Specification of Monthly Report CD-ROM for GMS data**

| Recording format: ISO9660 standard | | |
|---|---|---|
| Form | File format/size of image | Content |
| Tabular form data | File format: ASCII code | Cloud Amount<br>Sea Surface Temperature<br>Cloud Motion Wind<br>Water Vapor Motion Wind<br>Equivalent Blackbody Temperature<br>Out-going Longwave Radiation (OLR)<br>Solar Irradiation<br>Snow and Ice Index<br>GMS Attitude/Orbit Data<br>VISSR Image Data Catalog (CMT/Micro Film)<br>TOVS Vertical Profile of Temperature and Precipitable Water<br>TOVS Total Ozone Amount |
| GMS Full Disk Earth's Cloud Image | File format: Bitmap format available in Microsoft® Windows® operating system<br>Size of image: 512 pixels by 512 lines and 256 levels | Infrared (IR:11μm): 6-hourly and 03UTC<br>Visible (VS): 00, 03 and 06UTC<br>Water Vapor (WV): 6-hourly and 03UTC |
| GMS Cloud Image of Japan and its Vicinity | File format: Bitmap format available in Microsoft® Windows® operating system<br>Covering area: 50N-20N and 120E-150E at every 0.06 degrees latitude by 0.06 degrees longitude box<br>Size of image: 501 pixels by 501 lines and 256 levels | Visible(VS): hourly (from 21 UTC to 09 UTC; 13 images/day )<br>Infrared (IR:11μm): hourly (24 images/day)<br>Water Vapor (WV): hourly (24 images/day)<br>Infrared (3.7 μm): hourly (from 09 UTC to 21 UTC; 13 images/day) |

* (These images can be viewed by the Viewer contained in the CD-ROM)

Note: The Monthly Report CD-ROM has been issued every month since July 1996.

### 8.2.4. PRC

A new generation data archiving system had been set up in 1998. This system is a Unix-Based system. It consists of two HP Unix Severs model K570 with 512MB memory and 50GB online disk array. The near-line storage is an auto tape library from Storage Technology Limited. Three tape drivers install within the library. They can record and read data concurrently. The peak value of data access rate is 14MBps per driver. Three different density tapes are used to record different satellite data. The first one is 10GB. The second one is 25GB. The third one is 50GB. This library can hold up to 936 cartridges. So the maximum capacity of the library is above 45TB. Raw data of polar satellite FY-1C, NOAA-14, NOAA-15 and geostationary satellite GMS-5, FY-2 as well as products derived from satellite data such as TOVS, SST, OLR are recorded into this library since May 1999. Veritas Company's NetBackup is used for data backup and HSM for data migration respectively. CMA plans to read out historic data which recorded on IBM 3480 tape and reformat them according to new data format and standard, record them into STK library within coming two years.

A catalogue of all available data can be found at http://www.cma.gov.cn.

### 8.2.5. Russia

Long-term archives of data and products (since 1979) from the meteorological (Meteor, GOMS/Electro) oceanographic (Okean) and earth resources (Resurs) satellites are maintained by SRC Planeta (7, B. Predtechensky per., Moscow, 123242, Russia). A photographic archive contains data from 1979 to 1995 and a digital images archive from 1991 up to the present.

Historical archives of meteorological satellite data and products are stored at the Scientific and Research Institute of Hydrometeorological Information – World Data Center (RIHMI-WDC, 6, ul. Koroleva, Obninsk Kaluzhskoy obl., 249020, Russia).

Users are allowed free and operational access to data catalogues including imagery quick-looks at SRC Planeta Internet server http://sputnik1.infospace.ru. Catalogues are updated in real time upon receipt of new data.

### 8.2.6. USA

NOAA is responsible for the collection and management of a rapidly increasing amount of data and information. This data and information encompasses all of NOAA's activities and includes holdings of climatological, geophysical, oceanographic, marine fisheries, hydrographic, and cartographic records. Much of this data is held and archived in NOAA's National Data Centres: the National Climatic Data Centre, the National Geophysical Data Centre, and the National Oceanographic Data Centre. Some of the data is stored by NOAA's Line Offices or by the office or scientist who originally collected it. Data is stored on a variety of media, but is generally considered to be of one of three types: paper, film, or digital.

A NOAA-wide program, the Environmental Services Information and Data Management (ESDIM) Program, was created in response to the NOAA Under Secretary for Oceans and Atmosphere's concern about data management in the organisation. Data management in NOAA deals with acquiring, quality controlling, preserving, storing, and providing user access to its data holdings. A study by NOAA's Advisory Panel on Climate and Global Change was commissioned in 1989 to review NOAA's data management and to make recommendations for more effective information management. The panel's February 1990 report, along with a November 1990 GAO report, "Environmental Data: Major Effort Needed to Improve NOAA's Data Management and Archiving", were the catalysts that started NOAA's ESDIM Program in early 1991.

Originally part of the Office of the Chief Scientist, the ESDIM Program was soon transferred to NOAA's National Environmental Satellite, Data, and Information Service (NESDIS), Office of Environmental Information Services (EIS), where it is located today. The ESDIM Program is responsible for selecting and funding data management projects to be accomplished by NOAA. The ESDIM Program has a small permanent staff that runs the day to day operations and has a team of advisors from NOAA's Line and Program Offices, that reviews data management project proposals and selects the projects the ESDIM Program will support in the upcoming year.

During the early years, the ESDIM Program concentrated on data rescue. Data rescue is the saving or salvaging of data on paper, film, or digital media, that would otherwise be lost, converting it to a stable, useable media, and then archiving and/or making it available for access.

NOAA's data includes paper records from the beginning of our country's history through the present time. Paper deteriorates over time depending on the physical properties of the paper and the conditions under which they were stored. Microfilm and microfiche, used to rescue deteriorating paper records, are themselves susceptible to deterioration and must be rescued. Digital media is used to rescue paper and film records and to store newly acquired data. . Digital media is also susceptible to deterioration. Data stored on older, less dense magnetic tape are being rescued to denser, smaller sized tape cartridges or to optical media. In time, data stored on today's best media will have to be rescued.

The amount of new data to be archived is rapidly increasing as new data collection systems are placed into service. These new systems include satellites and NEXRAD weather radars. To archive this data, it must be converted from the original media, particular to the collection system, to the data centre's archival media. This conversion is also data rescue.

In recent years access to NOAA's data and information has become a significant area of concentration for the ESDIM Program. Access is the process of making available data and information held by an individual, office, or organisation to a much larger audience. To access data it is necessary to know what data is available and where it is located. This is being accomplished by ESDIM with the online NOAA Environmental Services Data Directory (Earth System Monitor, December 1996, pp 6-8). The NOAA Directory catalogues the metadata, or data about the data, for NOAA's data holdings in Federal Geographic Data Committee (FGDC) Metadata Standard format. An online search for locating NOAA data, using any word in the data description, can be performed at the NOAA Directory Web site, http://www.esdim.noaa.gov/NOAA-Catalog/.

Providing web access to distributed NOAA data and information through a single Web site is NOAA Server, an ESDIM supported project. Participants in the development of NOAA Server include representatives from all of the NOAA Line Offices. A limited but growing portion of NOAA's data and information is presently available through this system at http://www.esdim.noaa.gov/NOAAServer/.

Further information about the history of the ESDIM Program can be obtained by visiting our Web site at http://www.esdim.noaa.gov/esdim/.

#### 8.2.6.1. National Geophysical Data Center

The National Geophysical Data Center (NGDC) in Boulder, Colorado is one of three NOAA National Data Centers within the National Environmental Satellite, Data and Information Service (NESDIS). NGDC's mission of managing environmental data includes data processing, archiving, distribution, and analysis. NGDC activities support research, education, government, and the public availability of its geophysical data whose scope covers solar-terrestrial physics, snow and ice, solid earth geophysics, and marine geology and geophysics.

The Center works closely with data contributors in preparing documented and reliable data sets. NGDC promotes cooperative projects with other government agencies, non-profit organizations, and universities, and it welcomes data exchanges. It interacts with foreign scientists through the World Data Center system operated by the International Council of Scientific Unions. This international exchange accords scientists from around the world access to global databases.

NGDC's current data holdings contain more than 300 digital and analogue databases, some of which are very large. Data sets of particular interest to CGMS are operational satellite data from the Defense Meteorological Satellite Program (DMSP), space environmental data from the Geostationary Operational Environmental Satellite system (GOES), and from the Polar-orbiting Operational Environmental Satellite system satellites (POES). Four DMSP satellites currently provide raw data records that are processed into archives at NGDC. NOAA's Space Environment Center (SEC) provides archive quality data from two GOES and two POES satellites. The instrumental databases are as follows:

- DMSP visible and infrared imagery - The Operational Linescan Imagery records broadband visible and thermal infrared emissions and reflections by day and by night from clouds, land surface, auroras, cities, wildfires, boats, and gas flares. The analogue archive begins with 1972 imagery. The digital archive begins with 1992 data.

- DMSP space environment data. Three sensors monitor electrically-charged particle and field environment near the Earth. They are the Plasma Monitor, a Magnetometer, and Auroral Electron and Ion Detector. The digital archive begins with 1975 data.

- DMSP microwave imagery and sounder data. The operational satellites provide data from one microwave imager for cloud/snow/ice discrimination and two microwave sounders for profiles of temperature and humidity. The digital archive begins with 1992 data.

- GOES space environment data. The GOES Space Environment Monitor consists of three instruments: a magnetometer, an energetic charged particle detector and a solar x-ray telescope. The first Solar X-ray Imager was launched on GOES-12, which is in storage. The digital archive begins with 1977 data.

- POES space environment data. The POES Space Environment Monitor monitors the flux of low-, medium- and high-energy electrically-charged particles. The digital archive begins with 1974 data.

New technologies allow NOAA National Data Centers to provide better services to more customers in a more cost effective and timely manner. NGDC preserves current data and migrates older data to near-line storage robotic systems. Routine services are being automated and augmented with tools that allow users to browse, visualize, order and receive the data electronically. As Geographic Information Systems are used by more and more clients NESDIS and NGDC databases are being migrated to GIS compatible formats. New techniques allow users to mine information from archives using search tools. Online data and products are available at http://www.ngdc.noaa.gov.

NGDC offers a wide range of standard and custom data products. Popular products include CD-ROMs, posters, publications, and slide sets.

Standard products can be ordered directly from the NOAA National Data Centers' Online Store. The store is operated on a secure server that allows it to accept credit card orders.

NGDC staff provides personal assistance by telephone, e-mail, fax, and by mail. Names of contacts along with phone number, e-mail address, fax number, and mailing address are listed at the bottom of the web page being viewed. NGDC can be contacted at info@ngdc.noaa.gov. Information about NGDC's mission and services can be found on the NGDC web page at: http://www.ngdc.noaa.gov/.

### 8.2.6.2. National Oceanographic Data Center

The National Oceanographic Data Centre (NODC) is one of the national environmental data centres operated by the National Oceanic and Atmospheric Administration (NOAA) of the U.S. Department of Commerce. The main NODC facility is located in Silver Spring, Maryland. The NODC also has field offices collocated with major government or academic oceanographic laboratories in Woods Hole, MA; Miami, FL; La Jolla, CA; Seattle, WA, and Honolulu, Hawaii.

The NODC is responsible for the full range of data management services for physical, chemical and biological oceanographic data generated by domestic and foreign activities. NODC makes these data, as well as derived products and information, available to all public and private sector interests. NODC represents NESDIS in interagency activities through service on technical panels, committees and councils; and as delegated, represents the United States in international organisations on matters involving oceanographic data. As requested, NODC also provides specialised data management services for oceanographic research and observational programs sponsored by other agencies.

**International Activities**

A large percentage of the oceanographic data held by NODC is of foreign origin. NODC acquires foreign data through direct bilateral exchanges with other countries and through the facilities of World Data Center (WDC), Oceanography, which is operated by NODC under the auspices of the U.S. National Academy of Sciences. There are three World Data Centers for Oceanography:

- World Data Centre, Silver Spring, Maryland, United States,
- World Data Centre, Moscow, Russia, and
- World Data Centre, Tianjin, People's Republic of China.

They are part of the World Data Centre System initiated in 1957 to provide a mechanism for data exchange during the International Geophysical Year. The World Data Centre System operates under guidelines issued by the International Council of Scientific Unions (ICSU).

**NOAA Central Library and Information Network**

The NODC also manages the NOAA Library and Information Network, which includes the NOAA Central Library in Silver Spring, MD; regional libraries in Miami, FL and Seattle, WA. It also coordinates library services among field libraries or information centres at about 30 NOAA sites throughout the United States. The combined libraries contain more than 1 million volumes, including books, journals, data and information CD-ROMs, and audio and videotapes.

**What happens to data that is submitted to NODC?**

An original dataset that is submitted to the National Oceanographic Data Centre becomes part of the NODC archive when it is given an NODC Accession Number and is copied to archival media. Metadata about the original dataset submission are generated and electronically filed. Additional metadata, such as publications relevant to the original data, are forwarded to the NOAA Central Library. The NODC Catalogue General Query Web page allows users to search a high-level summary inventory of the NODC's data set holdings. Additional detailed output that complies with the FGDC Content Standard for Digital Geospatial Metadata will soon be available for individual accessions.

Some original data are processed for inclusion in a variety of data products (such as the NODC Ocean Profile Database, World Ocean Database, or the Global Temperature-Salinity Profile Program). One advantage to using these products, rather than multiple original data accessions, is that these products provide data in a consistent format which makes manipulating the data easier. Data values are not changed during processing to standard NODC products.

A complete set of products and services for the National Oceanographic Data Centre can be found on the Internet at http://www.nodc.noaa.gov. The NOAA National Data Centres http://nndc.noaa.gov/home.shtml and the NOAA Server Project (http://www.esdim.noaa.gov/noaaserver-bin/NOAAServer?stype=home) provide additional access to a growing set of specific NODC data products and online databases.

### 8.2.6.3. National Climatic Data Centre

The National Climatic Data Center (NCDC) manages a vast resource of environmental satellite data and derived products from NOAA's Geostationary Operational Environmental Satellites (GOES) and Polar-orbiting Operational Environmental Satellites (POES). NCDC's environmental satellite databases are elements of the overall National Environmental Satellite, Data and Information Service's (NESDIS) environmental databases, part of which contains well over 450 terabytes of digital data and products beginning as early as 1974. Also, data from various NASA research satellites and Department of Defense Meteorological Satellite Program (DMSP) satellites are part of this vast database. More information on NCDC's satellite resources can be viewed on the Web at http://www.ncdc.noaa.gov at the Satellite Resources page.

In the near future, the NCDC archive of satellite data will continue to grow considerably. The NCDC will begin archiving National Aeronautics and Space Administration (NASA) Earth Observing Satellite (EOS) data. In addition, NCDC will begin archiving some EUMETSAT data and data from the National Polar Operational Environmental Satellite System (NPOESS), which results from the merging of the POES and DMSP satellite missions.

Over the last couple of years, the NCDC migrated its POES and DMSP tape holdings to a robotics mass storage system for easy access and future migrations. Data are now accessible within minutes and hours versus hours and days previously.

NCDC offers several means to retrieve retrospective satellite data and products. For large satellite orders, data will be provided on physical media such as magnetic tape or CDs. Smaller orders can be delivered via anonymous file transfer protocol (FTP), which saves delivery time and costs. As Internet bandwidth continues to grow, users are encouraged to retrieve larger volumes of data via FTP.

NESDIS is building the Comprehensive Large-array Access and Stewardship System (CLASS). CLASS will provide long-term stewardship of the large array data. CLASS will initially include the Satellite Active Archive and the GOES Active Archive and be expanded to include other large array remotely sensed data sets (NASA EOS, DMSP, NPOESS, weather radar data, etc.). The new system will include on-line ordering of data for immediate on-line delivery or for placement on off-line media.

**Retrieval of Archived Data**

A subset of POES data are available on-line through the Satellite Active Archive (http://www.saa.noaa.gov). NCDC is building a GOES Active Archive (GAA), similar to the Satellite Active Archive (http://www.saa.noaa.gov) which will allow users to access GOES data inventory, preview browse images, make selections for specific dates, times, areas, and channels, and to download selected data sets via FTP. The GAA is scheduled for operations during mid 2003. Earlier this year, NCDC began archiving GOES data and products in a robotics storage system, which is the first step to give users easier access to the GOES archive. Historical data (1974 to 1997) contained on Sony U-matic tapes have been rescued and will be migrated to the robotics system over the next year.

DMSP data are available at both the NCDC and the National Geophysical Data Center (www.ngdc.noaa.gov).

All of the POES Level 1B data have already been migrated to the robotics system making it easier to retrieve. During the next year, NCDC will implement the same functionality for POES data as is available at the SAA.

Requests for satellite data, products, and documentation should be addressed to:

National Climatic Data Center
Attn: Satellite Services Group, Room 120
151 Patton Avenue
Asheville, North Carolina 28801-5001
U.S.A.
Phone number: 828-271-4850
Fax number: 828-271-4876
E-mail address: NCDC.satorder@noaa.gov

There are a number of satellite products that users can access via the NCDC web services. These services are listed at

http://www.ncdc.noaa.gov/ol/satellite/satellitedata.html.

Additional data are available from the NCDC web site under Satellite Resources:

- Historical GOES Browse Server - daily images since July 1992
- Satellite Active Archive - Lev 1b POES and DMSP data - since January 1981
- Historical Significant Event Images - special images of major events
- DMSP SSM/I Global Gridded Data via anonymous FTP - from 1987 to present
- SSM/I Monthly Image Products - surface wetness, surface temperature, and snow cover - from 1988 to present
- Satellite's Eye Art Galleries - discussions and images

Also, a number of satellite data user's guides are online at:

www.ncdc.noaa.gov/ol/satellite/satelliteproducts.html

These include:

- Polar Orbiter Data User's Guide
- NOAA KLM User's Guide
- International Satellite Cloud Climatology Project (ISCCP) Catalog of Data and Products
- NOAA Global Vegetation Index User's Guide.

### 8.2.6.4. Satellite Active Archive

The National Oceanic and Atmospheric Administration (NOAA) Satellite Active Archive (SAA) is NOAA's premier on-line facility for the distribution of NOAA and U. S. Department of Defence (DoD) Polar-Orbiting Environmental Satellite (POES) data and derived data products. Operated by the Information Processing Division (IPD) of the Office of Satellite Data Processing and Distribution (OSDPD), the SAA is currently supported by funding allocated through NOAA's Strategic Initiative for Seasonal-to-Inter-annual Climate Change. Additional resources are provided through the NOAA Earth System Data and Information Management (ESDIM) Program Office, the National Ice Centre (NIC), and NOAA's Office of Research and Applications (ORA) for specific data management and data distribution services. Progress and performance are tracked through the NOAA-wide Information Technology (IT) initiative planning process by the NOAA Office of Administration as well as through the National Environmental Satellite, Data, and Information Service (NESDIS) Fiscal Year Operating Plan. NESDIS is the parent organisation of OSDPD.

The SAA is currently operated and maintained by a staff of one (1) government employee and twelve (12) contractor personnel under IPD's Central Satellite Data Processing (CSDP) contract with Computer Sciences Corporation (CSC). Government personnel are responsible for managing the programmatic, technical, and administrative functions of the SAA, while the contractor staff is responsible for daily operations, adaptive maintenance, and development of SAA systems. Both the government and contractor teams share responsibilities for short- and long-term system planning and for daily system monitoring and customer interaction.

The SAA also maintains an active partnership with NOAA's National Climatic Data Centre (NCDC). NCDC, the permanent U. S. archive for POES data and derived data products, supports the SAA through a user-interactive Help Desk facility and through the provision of POES supporting documentation, including the NOAA Polar-orbiting Data (POD) User's Guide. Additionally, NCDC and SAA share data distribution responsibilities for Defense Meteorological Satellite Program (DMSP) data under a Memorandum of Understanding with the National Aeronautics and Space Administration (NASA) for the Earth Observing System (EOS) Program.

The SAA is implemented with a modern client-server architecture composed of clustered UNIX processors closely coupled with the IPD Enterprise Server (IPD/ES), a robotic tape library, and several dedicated and broad-band telecommunications hubs. The SAA provides data to customers in three basic modes: user-interactive access (aperiodic, customer-selected criteria); automated distribution (periodic, customer predefined criteria); and subscription services (event-driven, customer-defined criteria). Interactive access is provided through a World Wide Web (WWW) server. Automated and subscription distributions are commonly processed through automated FTP services established through direct interface with the individual customer(s). Visit our Web site at http://www.saa.noaa.gov/ for additional information.

## Background

The NOAA Satellite Active Archive (SAA), established as a demonstration prototype for electronic distribution of POES data in 1994, became operational in July 1995. During that first month, 379 Advanced Very High Resolution Radiometer (AVHRR) Level 1b data sets were distributed to 27 customers via the emerging Internet. In the roughly five years since that first operational distribution, average monthly volume has increased to over 40,000 data sets and the SAA customer base stands at more than 8,400 registered customers. The active archive has been expanded during that period to include TIROS Operational Vertical Sounder (TOVS) data, Defence Meteorological Satellite Program (DMSP) data, Radarsat Synthetic Aperture Radar (SAR) imagery, operational (near-term) satellite-derived products, and climatic (time series) satellite-derived products. The SAA now provides on-line access to over 83 percent of the available NOAA POES and DMSP data from 1978 to present. In addition, the SAA functions as an Information Technology (IT) platform for the distribution of prototype satellite derived products, such as NOAA's Geostationary-Orbiting Environmental Satellite (GOES) Sea Surface Temperature (SST).

The SAA has been developed and implemented through a series of planned technology "releases." During its initial era (1993-1995), the prototype SAA was implemented as Releases 0.1 through 0.6 with several major engineering accomplishments including the integration of UNIX client-server processors within the traditional IPD mainframe environment; the utilisation of a robotic tape library for retrospective data storage and selection; the use of "on-line browse" imagery for data pre-screening; and the re-engineering of existing government data access and distribution software to meet the unique needs of the potential SAA POES clientele.

From 1995 through 2000, the operational SAA has evolved under 13 major Releases (1.0 through 2.4) and several minor or maintenance Releases. These operational releases included the expansion of data availability from AVHRR to TOVS, DMSP, Radarsat, and operational and climatic satellite-derived products; the development and refinement of the SAA World Wide Web (WWW) interface; the automation of direct and subscription services;

the implementation of object-oriented software technologies; the substantial upgrade of the spatial search capabilities; and the implementation under an IBM RS/6000 Shared Processor (SP) hardware environment. With these releases, the SAA has achieved or exceeded all of its 5-year operational goals.

## Current Status

The SAA is a fully operational system within OSDPD/IPD. In CY 1999 the SAA electronically distributed over 5 terabytes of polar satellite data and derived data products to its customers. In 1998, major upgrades to the IPD hardware architecture included the replacement of the central mainframe computer with a state-of-the-art enterprise server; the upgrade of the SAA robotic tape storage and retrieval system; and the replacement of outmoded SAA UNIX servers with state-of-the-art IBM SP/2 processors "closely coupled" to the enterprise server. Additionally, the SAA increased on-line storage capacity by 360 gigabytes with the acquisition of a high capacity magnetic disk array for the dedicated storage of satellite browse imagery.

In FY 1998 the SAA began the implementation of new software systems which couple commercial off-the-shelf (COTS) relational database software with SAA-developed, object-oriented (OO) code to replace the then existing client-server operations. System Release 1.6 was the initial phase of the OO implementation and coincided with the launch of and subsequent data distribution from NOAA-K (now NOAA-15). Release 2.2 in FY 2000 completed the implementation of the OO architecture. Release 2.0 integrated the new IBM SP hardware architecture to form the basis for polar satellite data distribution through FY 2003.

The SP hardware architecture features high capacity disk caching and networked data storage. The current configuration is scaled at eight (8) central processors and may be expanded to 32 processors when and if required. This increased processing and data sharing capacity reduces end-to-end processing and I/O time significantly, thus reducing time between customer data requests and actual data delivery. Additionally, the processors will be configured to provide total operational server redundancy, virtually eliminating system downtime and providing uninterrupted customer access. Visit our website at http://www.saa.noaa.gov/ for additional information.

**System Description: Functional and Operational Capabilities**

The SAA provides functions in the following areas:

**Data Ingest and Archiving** - The SAA maintains an inventory database of AVHRR, TOVS, DMSP, and SAR data sets, and browse image files for AVHRR data. The SAA converts certain IPD product data sets, including Pathfinder products generated within the SAA, to NetCDF format and archives those files locally. The Historical Information Processing (HIP) system ingested AVHRR, TOVS, and DMSP data sets obtained between 1978 and 1994. HIP uses SAA Ingest software to create operational SAA inventory records and browse images.

**Pathfinder Product Generation** - Pathfinder software within SAA generates atmospheric data products from AVHRR 1b data sets. These products are made available to users through an FTP server, and some products are available through the SAA WWW interface.

**Product Distribution** - The SAA enables users to search for inventoried and archived data sets, list summary data set information, and display browse images through WWW browsers. The Ferret/LAS component of the WWW interface provides various graphic representations of product data and enables users to download that data. The SAA enables users to order AVHRR, TOVS, and DMSP 1b data sets and DMSP SSMI product data sets, which can be delivered electronically via FTP. The SAA also has the capability to push data to subscribers.

**Operations Monitoring** - The SAA includes a variety of tools that enable operators to monitor the status of system hardware and software components, to detect and analyze problems with the ingest, archiving, or delivery of data sets, to reinitiate the ingest of selected data sets, to resubmit failed orders, and to generate statistics of system usage. An Operator Interface, accessible through a WWW browser, provides all of these functions and facilitates system monitoring and maintenance. See our web page http://www.saa.noaa.gov/ for additional information.