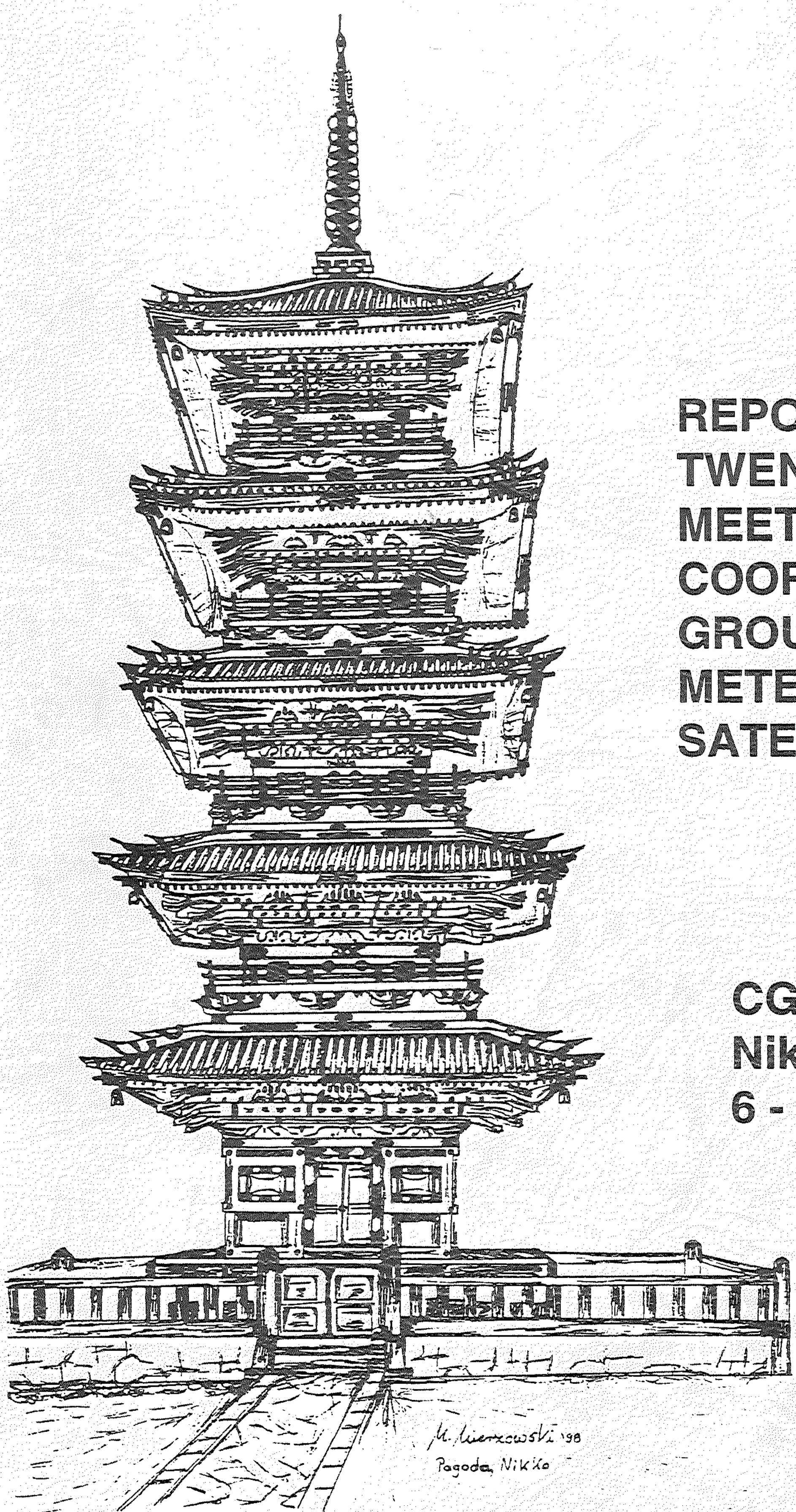
CGMS

REPORT OF THE TWENTY-SIXTH MEETING OF THE COORDINATION GROUP FOR METEOROLOGICAL SATELLITES



CGMS XXVI
Nikko, Japan
6 - 10 July 1998

REPORT OF THE TWENTY-SIXTH MEETING OF THE COORDINATION GROUP FOR METEOROLOGICAL SATELLITES

CGMS XXVI

Nikko, Japan, 6-10 July 1998

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TABLE OF CONTENTS

Page

Report of the meeting of CGMS XXVI

Appendix A: Selected papers submitted to CGMS XXVI

Appendix B: General CGMS information

Tables included in the Report

TWENTY-SIXTH MEETING OF THE CGMS
FINAL REPORT OF THE PLENARY SESSION

A. INTRODUCTION

A.1 Welcome

CGMS-XXVI was convened by Japan Meteorological Agency at 14:00 p.m. on 6 July 1998 in Nikko Lakeside Hotel. On behalf of the Director-General of JMA, Mr. Itoh, Director of the Meteorological Satellite Center of JMA, welcomed the delegations from EUMETSAT, India, the People's Republic of China (PRC), Russia, the United States, and WMO. He expressed his pleasure to be able to host this twenty-sixth session of the Co-ordination Group for Meteorological Satellites.

Mr. Itoh recalled the progress made by CGMS since its creation 26 years ago. He was glad to note that over this time WMO and a growing number of satellite operators were able to contribute to the work of CGMS. In this respect Mr. Itoh in particular mentioned the technical achievements and the cooperative spirit developed with the group.

Mr. Itoh pointed out that satellite systems coordinated by CGMS are an essential component of the World Weather Watch. In Japan, meteorological satellites are also an essential support to disaster monitoring, e.g. typhoons, earthquakes, and tsunami warnings. He welcomed the new participants at this meeting and wished all an enjoyable stay in Japan in the beautiful area of Nikko.

A.2 Election of Chairman

Mr. Itoh was unanimously nominated as Chairman of CGMS XXVI and Dr. Hinsman as Co-chairman.

Dr. Hinsman thanked JMA for hosting the meeting. He noted with satisfaction that all CGMS satellite operators were represented in this plenary meeting and thanked them for their participation.

A.3 Adoption of Agenda and Work Plan of W/G Sessions

The Agenda (See Annex 1) was adopted. It was agreed that Working Groups I and II, dealing with telecommunications and satellite products, respectively, would work in parallel on Wednesday morning, while Working Group III dealing with Satellite Tracked Winds, would meet on Tuesday afternoon.

The Secretariat provided a list of working papers submitted to CGMS XXVI, together with a provisional order of business; which was used as a basis for subsequent discussions.

A.4 Nomination of WG Chairmen, Rapporteurs and Drafting Committee

The following were nominated as Chairmen for the Working Groups:

- WG I (Telecommunications) - Mr. Robert Wolf
- WG II (Satellite Products) - Dr. Paul Menzel
- WG III (Satellite Tracked Winds) - Mr. Nobuo Sato

In the course of the meeting, when addressing agenda item D, it was further agreed to set up the following working group:

- WG IV (Contingency Planning) - Dr. Tillmann Mohr

A Drafting Committee was appointed, comprising Mr. Gordon Bridge, Dr. Donald Hinsman, Dr. Nobuo Sato, Dr. Alexander Uspensky, Mr. Robert Masters, Dr. H.V. Gupta and Prof. Xu Jianping. All CGMS Members were invited to provide inputs to the final report through this drafting committee.

A.5 Review of Action Items from Previous Meetings

The Secretariat reminded participants of the outstanding actions from previous meetings, taking into account inputs provided in EUM-WP-01, JAPAN-WP-01, RUS-WP-00, USA-WP-01 and WMO-WP-02. All these actions were then reviewed as follows:

(i) Permanent actions

1. *The Secretariat to review the tables of current and planned polar and geostationary satellites, and to distribute this updated information, via the WWW Operational Newsletter, via Electronic Bulletin Board, or other means as appropriate.*

   This information has been made available on-line on the CGMS home page. It also has been published in the Final Report of CGMS-XXV. A further update is submitted to CGMS-XXVI for review.

2. *All satellite operators to circulate regular satellite operational reports.*

   This is routinely done.

3. *All satellite operators to provide NOAA/NESDIS with information on unexplained anomalies for study, and NOAA to provide solar event information to the satellite operators on request and a status report on the correlation study at each meeting.*

   Information on anomalies are presented under agenda item B.3 in USA-WP-03.

4. *USA to issue quarterly to all other admitting authorities the consolidated DCP assignments.*

This is routinely done.

5. *All satellite operators to regularly provide WMO with information on the number of meteorological satellite reception stations in their areas of responsibility.*

This is routinely done by most of the operators. WMO recalled the importance of this information, e.g. for frequency protection.

6. *All CGMS Members to inform users to register user stations within their area of responsibility.*

This is routinely done.

7. *CGMS Members generating Satellite Tracked Winds to check that the following monthly statistics are sent and received on a quarterly basis via the CGMS server supported by WMO: number of co-locations, temporal and spatial co-location thresholds, and radiosonde inclusion/exclusion criteria.*

CGMS stressed the importance of this action. WMO proposed to make these statistics available on the WMO home page.

(ii) Outstanding actions from previous meetings

ACTION 24.11 *NOAA to provide to all CGMS Members its design specifications and certification procedures for 300 bps DCP before CGMS XXVI.*

Closed. Design specifications and certification procedures relating to 300 and 1200 bps DCP were received from NOAA in March 1998.

ACTION 24.12 *CGMS Members to review and provide comments to NOAA regarding NOAA's 300 bps DCP design and certification procedures, before CGMS XXVI.*

Closed. This is re-formulated as ACTION 26.01.

ACTION 24.13 *NOAA to present at CGMS XXVI, a proposed design and certification plan for 300 bps DCPs for acceptance as a "standard" by CGMS Members at CGMS XXVI.*

Closed. This is re-formulated as ACTION 26.02.

ACTION 26.01 CGMS Members to review and provide comments to NOAA regarding NOAA's 300 bps and 1200 bps DCP design and certification procedures, by 31 August 1998.

ACTION 26.02 **NOAA to propose a design and certification plan for 300 bps DCPs for acceptance as a "standard" by CGMS Members at CGMS XXVII.**

(iii) Actions from CGMS XXV

ACTION 25.01 *Russia to provide CGMS Secretariat by 1 July 1997, with description of their raw image data transmission from GOMS.*

Closed. Letter sent on 18/08/97 circulated to Members.

ACTION 25.02 *EUMETSAT to circulate by 1 July 1997 to Russia, PRC and Japan a copy of the EUMETSAT-NOAA bilateral agreement on contingency back-up, to be used as a reference for future contingency arrangements.*

Closed. Information sent on 2 July 1997.

ACTION 25.03 *All operators to report at CGMS XXVI about the outcome of on the possibility to develop regional contingency arrangements.*

Closed. JAPAN-WP-04 and PRC-WP-05 report on the outcome of such consultations.

ACTION 25.04 *WMO to present the Statement of Guidance on Feasibility of Meeting Requirements to CGMS XXVI.*

Closed. This is provided in WMO-WP-07 to be discussed under item E.1.

ACTION 25.05 *EUMETSAT to provide CGMS Members with direct FTP access, via Internet, to the IDCS database.*

Open. It is planned to provide this access in the course of 1998. EUM-WP-08 refers to this action.

ACTION 25.06 *Japan, with the assistance of the CGMS Secretariat, to identify a DCP observation data set and analysis scheme, suitable for an IDCS end-to-end system test.*

Closed. Data set has been compiled. Discussion under item F.1.

ACTION 25.07 *USA, with the assistance of the CGMS Secretariat, to develop a primary set of reporting statistics on IDCS performance to be provided as feedback to DCP Operators and the WMO on a quarterly basis.*

Open. Follow-on action of 25.06. Quarterly reports for monitoring interference on IDCS channel were not available due to failures with the monitoring equipment. A new deadline has been fixed for the 31 August 1998.

ACTION 25.08 *CGMS Secretariat, with the assistance of WMO, to implement an IDCS end-to-end system test at the time of the regular WMO monitoring of the GTS in the period 1-15 October 1997, and report results to CGMS XXVI.*

Open. The full IDCS end-to-end system test has been postponed to 15/10/98. The action is closed for SYNOP and TEMP messages only. Reference to this action is made in WMO-WP-08.

ACTION 25.09 *WMO to distribute the results of IDCS end-to-end system tests to the appropriate bodies with WMO (e.g. CMM and CBS).*

Open. Pending completion of ACTION 25.08. Closed for SHIP and TEMPSHIP messages only, reference data set is being developed.

ACTION 25.10 *CGMS Members to provide the Secretariat with proposals for an expansion of the IDCS in the year 2000 time frame.*

Closed. EUM submitted a proposal on 9/07/97, JAPAN-WP-06 presents a proposal. These proposals will be discussed under agenda item F.1.

ACTION 25.11 *CGMS Members to inform the Secretariat of any revision or corrections to the IDCS User Guide (Issue 7) by 30 September 1997.*

Closed. Input received from Japan. Further input will be provided by USA and WMO when discussing agenda item F.1.

ACTION 25.12 *CGMS Secretariat to prepare an update of the IDCS guide for review by CGMS Members at CGMS XXVI.*

Closed. Revision of IDCS guide has been prepared based on input received from Japan. A preview draft has been sent out for comments on 23/04/98.

ACTION 25.13 *WMO to provide Russia with the detailed information necessary to process ASDAR data, by 31 July 1997.*

Closed. WMO sent information by E-mail on 19/07/97.

ACTION 25.14 *The USA to convene a special meeting of experts with* *participation of EUMETSAT, ESA and WMO, on the LRPT specification, by 30 September 1997.*

Closed. Special meeting was convened on 10-11/12/97 to review the draft LRPT specification.

ACTION 25.15 *All CGMS Members to review the draft LRPT Specification proposed in CGMS XXV EUM-WP-09 by 1 January 1998.*

Closed. The USA reviewed the draft specifications and expressed comments, which were discussed with EUMETSAT, ESA and WMO in December 1997. A revised draft LRPT specification will be presented at CGMS XXVI by EUMETSAT in EUM-WP-09.

ACTION 25.16 *CGMS satellite operators to review the draft initial requirements developed by the Chairman of the CBS WG SAT Subgroup on Small Workstations for the Application and Presentation Layer Specifications for LRIT/LRPT/HRIT/HRPT Data Format, and provide comments to WMO by 1 November 1997.*

Closed. Comments were received from EUMETSAT, Japan, PRC, USA.

ACTION 25.17 *CGMS Members to review by 30 September 1997 the proposed update to the LRIT/HRIT Global Specification Issue 2.4 and express comments or approval to EUMETSAT.*

Closed. EUM-WP-28 reports on current status of LRIT/HRIT Global Specification. Comments received from Japan. Further comments will be made when discussing item G.1

ACTION 25.18 *All CGMS Members to inform the Secretariat of any change in the status or plans of their satellites to allow the updating of the CGMS Tables of Satellites.*

Closed. Updates have been provided by EUMETSAT, NOAA and Japan. This action is now considered a permanent action.

ACTION 25.19 *WMO and EUMETSAT to jointly prepare the on-line distribution of CGMS Tables of Satellites.*

Closed. WMO has made this information available on the CGMS pages of the WMO server.

ACTION 25.20 *Russia to report at CGMS XXVI on its efforts to remove interference affecting the 401 – 403 MHz frequency band used for DCP.*

Closed. A report is provided in RUS-WP-06.

ACTION 25.21 *The CGMS Secretariat to contact CLS/ARGOS in order to seek information on the operation of long term future ARGOS services, including any possible expansion in use of frequency band by 30 September 1997.*

Closed. Letter sent to CLS/ARGOS on 28/07/97 and reply received on 7/08/97.

ACTION 25.22 *WMO to establish a list server for WRC 97 on the basis of participants list to be provided by CGMS Members. Details of server content to be provided to CGMS Members in the near future.*

Closed. List server for WRC 97 established in July 1997 (WRC-met@www.wmo.ch). WRC 97 is now over.

ACTION 25.23 *Russia to provide CGMS with information about the development of a DCP relay system operating at 1200 bps before CGMS XXVI.*

Closed. This is addressed in RUS-WP-07.

ACTION 25.24 *Japan to provide CGMS with information about its development of a DCP relay system operating at higher data rates before CGMS XXVI.*

Closed. This is addressed in JAPAN-WP-18.

ACTION 25.25 *CGMS Members to provide WMO with ideas on content and further enhancements of the CGMS home page before CGMS XXVI.*

Closed. WMO-WP-04 and EUM-WP-06 present proposals for enhancements. Comments received from NOAA on 12/06/98.

ACTION 25.26 *The USA to report on its development of integrated products at CGMS XXVI.*

Closed. This is reported in USA-WP-16.

ACTION 25.27 *The USA, EUMETSAT and Japan to report at CGMS XXVI on their continuing development work for the intercalibration of polar and geostationary satellites.*

Closed. USA-WP-20, USA-WP-22, JAPAN-WP-12 and EUM-WP-16 report on this issue.

ACTION 25.28 *CGMS Members also participating in the CEOS Cal/Val should* *ensure the complementarity of activities and report at CGMS and CEOS Cal/Val meetings as required.*

Closed. This is addressed in EUM-WP-17. This action is now considered a permanent action.

ACTION 25.29

Each CGMS operator to commence satellite intercalibration activities and to identify a coordinator for such activity before CGMS XXVI.

Closed. EUMETSAT, NOAA/NESDIS, JMA and PRC have commenced intercalibration activities. Russia will report on its intercalibration activities in Working Group II. The designated coordinators are Dr. Menzel (NOAA), Dr. Schmetz (EUMETSAT), Dr. Uspensky (Russia), Dr. Xu Jianping (PRC), Mr Kurihara (Japan) and Dr. Gupta (India).

ACTION 25.30

All CGMS satellite operators to request an AVHRR data set with the assistance of NOAA/NESDIS, for cross-calibration with their geostationary satellite, by 31 October 1997 and NOAA/NESDIS to provide the data on request.

Closed. GEO/LEO data set announced in January 1998 by NOAA. Data is provided on request.

ACTION 25.31

All CGMS satellite operators to report at CGMS XXVI on their additional cross-calibration activities using foreign satellite data.

Closed. NOAA (USA-WP-21), EUMETSAT (EUM-WP-16), Japan (JAPAN-WP-12) and China (PRC-WP-08) report on this issue. This will be discussed by Working Group II.

ACTION 25.32

EUMETSAT to provide at CGMS XXVI the results of initial tests by ECMWF of the forthcoming 4D-variational analysis.

Closed. EUM-WP-20 provides these results.

ACTION 25.33

All CGMS Members to report on their procedures for transferring into operation the results of their research on product development, at CGMS XXVI.

Closed. JMA in JAPAN-WP-15 and EUMETSAT in EUM-WP-21 report on their experience. USA reports on their procedures in Working Group II.

ACTION 25.34

All CGMS wind operators to present their wind product development plan at CGMS XXVI.

Closed. Japan (JAPAN-WP-17), EUMETSAT (EUM-WP-24), India (IND-WP-02) and NOAA (USA-WP-19) present such plans.

ACTION 25.35 *WMO to consider hosting the 4th International Workshop on Winds in Switzerland in 1998.*

Closed. The firth International Wind Workshop will be hosted by WMO in Saanenmöser on 20-23/10/1998.

ACTION 25.36 *CGMS Members to report quarterly winds statistics via the CGMS server supported by the WMO.*

Closed. EUMETSAT and NOAA report quarterly statistics, while Japan reports monthly statistics via the CGMS server.

ACTION 25.37 *CGMS wind operators to include all operational winds (low and high density) in the operational statistics following the approved reporting format.*

Closed. EUMETSAT, NOAA and Japan use this reporting format. JMA notes that in the vicinity of typhoons low level wind vectors are excluded from the statistics.

ACTION 25.38 *EUMETSAT to report at CGMS XXVI on the use of Satellite Tracked Winds at NWP Centres.*

Closed. EUM-WP-25 reports on this issue.

ACTION 25.39 *EUMETSAT to forward a formal and detailed proposal regarding the possible use of one IDCS channel to support the WMO-HYCOS project, and CGMS satellite operators to respond by 31 July 1997.*

Closed. EUMETSAT forwarded a proposal on 1/07/97. All CGMS satellite operators responded favourably.

B. REPORT ON THE STATUS OF CURRENT SATELLITE SYSTEM

B.1 Polar Orbiting Meteorological Satellite Systems

Russia informed CGMS in RUS-WP-01 on the status of the Meteor polar orbiting satellite system, which includes Meteor-2-21 launched in 1993 and Meteor-3-5 launched in 1991. These space systems provide the global observation of the earth surface in visible spectrum. On Meteor-2-21 and Meteor-3-5, the TV imagery data for global observation (MR-2000) are recorded and transmitted to the main receiving centres in

Moscow, Novosibirsk and Khabarovsk (466.5 MHz). The TV data from MR-900 scanning instruments is directly transmitted to receiving stations (APPI) at 137 MHz.

As described in USA-WP-02, NOAA is operating five polar orbiting satellites of the civilian POES programme and five of the Air Force DMSP programme. The current POES configuration includes two primary, one secondary, one stand-by spacecraft and one spacecraft in commissioning. The primary operational spacecraft, NOAA-12 and NOAA-14, are in sun-synchronous morning and afternoon orbits, respectively. The secondary spacecraft, NOAA-11, provides sounding data as back-up to NOAA-12, the stand-by spacecraft NOAA-10 supports minimal S&R functions and is only contacted once a week. The new spacecraft NOAA-15 launched in May 1998 is still in commissioning phase; it includes a new microwave atmospheric sounding package (AMSU-A1, AMSU-A2, AMSU-B) replacing MSU and SSU. Table 1 below summarises the POES satellites' payload.

NOAA-12 Morning orbit	NOAA-14 Afternoon orbit	NOAA-15 morning orbit
AVHRR/2 HIRS/2 MSU SEM DCS	AVHRR/2 HIRS/2 MSU SSU SEM DCS SBUV	AVHRR/3 HIRS/3 AMSU-A1 AMSU-A2 AMSU-B SEM DCS

TABLE 1: SUMMARY OF POES PAYLOAD

TABLE 2: CURRENT POLAR-ORBITING SATELLITES COORDINATED WITHIN CGMS

(as of July 1998)

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-15 (P)	USA/NOAA	7:30 (D)	05/98	Commissioning
	NOAA-12 (Op)	USA/NOAA	06:40 (D) 850 km	05/91	Functional (except sounding)
	NOAA-11 (Op)	USA/NOAA	07:20 (D)	09/88	Sounding only
	NOAA-10 (B)	USA/NOAA	10:00 (D) 840 km	12/86	Search and Rescue only
	DMSP-F14 (Op)	USA/NOAA	20:42 (A) 852 km	04/97	Defense satellite. Data partly available to civilian users
	DMSP-F12 (B)	USA/NOAA	21:13 (A)	8/94	Defense Satellite. Data partly available to civilian users
Sun-synchr. "Afternoon" (12:00 -16:00) (00:00 - 04:00)	NOAA-14 (Op)	USA/NOAA	14:00 (A) 850 km	12/94	Functional
Sun-synchr. "Early morning" (4:00 - 6:00) (16:00 - 18:00)	DMSP-F13 (Op)	USA/NOAA	17:40 (A) 850 km	03/97	Defense satellite. Data partly available to civilian users
	DMSP-F11 (B)	USA/NOAA	19:12 (A) 850 km	11/91	Defense Satellite. Data partly available to civilian users
Non sun-synchronous or unspecified orbits	METEOR 2-21 (Op)	Russia	950 km	08/93	Functional, except IR scanning instrument
	METEOR 3-5 (Op)	Russia	1200 km	08/91	Functional, except IR scanning instrument

B.2 Geostationary Meteorological Satellite Systems

EUMETSAT reported in EUM-WP-02 that Meteosat-7 is fully operational at 0°, Meteosat-6 is in stand-by mode, and Meteosat-5 is operated at 63° E in support of the Indian Ocean Experiment (INDOEX).

India reported (IND-WP-01) on the status of the Indian National Satellite (INSAT) System. INSAT satellites are three-axis stabilised operational multi-purpose spacecraft including meteorological payload, as well as telecommunications and broadcast services.

The operational INSAT system currently includes the first generation INSAT-1D (launched in 1990) and the second generation INSAT-2B (launched in 1993), while INSAT-2A is in stand-by mode. Both operational satellites provide VHRR imagery on a three hourly basis (VIS only on INSAT-2B) with a possibility of rapid scan on special weather situations, as well as half-hourly sequences at main synoptic hours for CMW derivation.

TABLE 3

	INSAT 1-D (83° E)	INSAT 2-A (74° E)	INSAT 2-B (93.5° E)
Horiz. Resolution (VIS)	2.75 km	2.0 km	
Horiz. Resolution (IR)	11 km	8.0 km	

The INSAT system provides a cyclone warning service and a Meteorological Data Dissemination (MDD) service, which delivers three hourly Wefax-type imagery and meteorological data operationally to some 90 domestic stations, using the 2599.225 MHz down-link frequency. CGMS noted that MDD reception from INSAT was authorised for any user in the INSAT field of view on a mutually agreed basis. INSAT also performs data collection and re-transmission from more than 100 DCP.

Japan reported on the status of GMS-5 and GMS-4 in JAPAN-WP-02. GMS-5 is stationed at 140° E above the equator and nominally performs VISSR (Visible and Infrared Spin-Scan Radiometer) observations producing 28 full-disk images per day, dissemination of cloud images and collection of meteorological data. GMS-4, stationed at 120° E as a back-up to the GMS-5, is maintained for possible nominal operation. Both satellites have enough fuel to continue their missions.

China (PRC-WP-01 and WP-02) reported on the successful launch of FY-2A on 10 June 1997 and provided details on the check-out activities, and the subsequent operation of the spacecraft, which delivered good quality imagery until April 1998 when a problem affected the antenna despin sub-system. It was noted that in the four-month operation period 2378 images were expected, 2347 were actually acquired and 2274 of them were of very good quality.

WMO expressed gratitude to all satellite operators and in particular to China for their efforts to develop and launch meteorological satellites and to overcome difficulties inherent in these activities. USA offered to share its experience with mechanical despun antenna systems with China.

Russia informed CGMS in RUS-WP-02 on the status of the GOMS-Elektro satellite. The attitude control system currently allows 95% availability of the spacecraft, which corresponds to a maximum of 17 IR images per day. No visible images can be acquired, due to a malfunction, which will be corrected on GOMS-Elektro-2.

Because of interference affecting the 401-403 MHz frequency band, the GOMS DCP mission can only be operated by the systematic repetition of DCP messages. The system will be further facilitated by increasing the DCP data rate to 1.2 kbit/s.

Russia informed CGMS that WEFAX dissemination via GOMS was temporarily suspended and images were being distributed via Internet at the following address: http://sputnik.infospace.ru.

WMO encouraged Russia to distribute all available images since imagery from this part of the globe was extremely valuable for meteorological forecasting.

The status of NOAA geostationary satellites GOES-8, -9, -10 were described in USA-WP-02. It recalled that the primary instrument payload for the current series of GOES spacecraft consists of an imager and a sounder. The latter provides data for atmospheric temperature and moisture profiles, surface and cloud top temperature and ozone distributions. Both instruments have the capability to sense stars during non-imaging times for use in Image Navigation and Registration (INR). In addition, the spacecraft can apply signals to the instrument servo-motors to compensate for repeatable long-term orbit and attitude effects. The GOES spacecraft also have Space Environmental Monitor (SEM) systems to measure magnetic fields, solar-X-ray flux and high-energy electrons, protons and alpha particles.

GOES-8 at 75° W is operating normally, although without redundancy on certain sub-systems. GOES-9 at 135° W was operating nominally up to the time of the meeting, again without redundancy on certain sub-systems. GOES-10 had to be rotated about its yaw axis by 180° in order to allow proper tracking by the solar array. After successful adjustment of the ground navigation and rectification software the spacecraft is now fully operational and was being kept in storage mode in a spin-stabilised passive attitude at 105° as a back-up for GOES-8 or -9. GOES-L is scheduled to be launched in May 1999 and join GOES-10 as in-orbit back-up.

TABLE 4 : CURRENT GEOSTATIONARY SATELLITES COORDINATED WITHIN CGMS

(as of July 1998)

Sector	Satellites currently in orbit (+type) P: Pre-operational Op: Operational B: Back-up L: Limited availability	Operator	Loca-tion	Launch date	Status
EAST-PACIFIC (180°W-108°W)	GOES-9 (Op)	US/NOAA	135°W	05/ 95	minor imager anomalies
WEST-ATLANTIC (108°W-36°W)	GOES-8 (Op) GOES-10 (B)	US/NOAA US/NOAA	75°W 105°W	04/ 94 04/97	minor sounder anomalies in stand-by
EAST ATLANTIC (36°W-36°E)	METEOSAT-6 (B) METEOSAT-7 (Op)	EUMETSAT EUMETSAT	0°	11/ 93 02/97	minor gain anomaly on IR imager Functional
INDIAN OCEAN (36°E-108°E)	METEOSAT-5 (Op) GOMS-N1 (P) FY-2 (L) INSAT II-B (L) INSAT I-D (L)	EUMETSAT RUSSIA CHINA INDIA INDIA	63°E 76°E 105°E 93.5°E 83°E	03/91 11/94 06/97 07/93 06/90	INDOEX Experiment, functional Disseminates 3-hourly IR images Experimental Satellite Cloud imagery for domestic use but wind products available on WMO GTS
WEST-PACIFIC (108°E-180°E)	GMS-5 (Op) GMS-4 (B)	JAPAN JAPAN	140° E 120°E	03/ 95 09/89	Operational In stand-by

B.3 Anomalies from solar and other events

USA-WP-03 indicated that solar particle events are expected to increase in frequency and importance in the years 2000-2002.

The USA recalled that a large amount of information is available from SEM measurements and from many years of recording satellite anomalies, and offered to share this information with any CGMS Member interested. The USA also encouraged CGMS Members to make use of solar activity warnings to avoid damage to the operational satellites. In addition to the expected increase in solar particle events, the USA noted the expected increase in meteor activity later this year from the Leonid meteor belt. CGMS proposed the following action:

ACTION 26.03 **All CGMS Members to inform the CGMS Secretariat by 15 September 1998 on any action planned to minimise the impact of the Leonid meteor storm expected in the Autumn of 1998, for posting on the CGMS home page.**

C. REPORT ON FUTURE SATELLITE SYSTEMS

C.1 Future Polar Orbiting Meteorological Satellite Systems

EUMETSAT reported in EUM-WP-03 that for the EUMETSAT Polar System (EPS), the Metop satellite was being developed as a joint project with ESA with a planned launch of Metop-1 expected in 2003. Ground segment development and integration was expected to start in 1998. The payload of Metop-1 will be provided in cooperation with NOAA, ESA and CNES and will include: AVHRR, HIRS, AMSU-A, MHS, IASI, ASCAT, GOME, GRAS, SEM and Search & Rescue. EUMETSAT added that pending approval by the EUMETSAT Council, only limited industrial activities had been authorised so far but full programme approval was expected in the course of 1998. The USA thanked EUMETSAT for the close and successful cooperation within the framework of the Initial Joint Polar System (IJPS).

China (PRC-WP-03) informed the meeting that its FY-1C polar orbiting satellite was in the process of being integrated and tested with an expected launch in 1999. The installation and test of the computer and network system was almost complete.

In RUS-WP-03 Russia reported on the development of the Meteor-3M-1 and Meteor-3M-2 satellites planned for launch in August 1999 and beyond 2000, respectively, on a sun-synchronous orbit. Meteor-3M-1 will have 9:15 hrs Equatorial Crossing Time. CGMS noted that Russia had developed a prototype for an interferometer operating at Nadir, and that the funding of a flight model for Meteor-3M-2 is under consideration. The microwave sounding instruments foreseen for Meteor-3M-1 and 2 are called MTVZA and MIVZA. Meteor-3M-2 will include HRPT dissemination capability and should fly a four-channel AVHRR like imaging radiometer called Multispectral Scanning Radiometer (MSR) with a horizontal resolution around 1 km. Russia also indicated that RESURS-01-4 will carry a meteorological payload including SCARAB and the MR-900 instrument (similar to that flown on Meteor-3M-1).

TABLE 5: FUTURE POLAR-ORBITING SATELLITES COORDINATED WITHIN CGMS

(as of July 1998)

Orbit type **(equatorial crossing times)**	**Future Additional Satellites**	**Operator**	**Planned launch date**	**Other information**
Sun-synchr. "Morning" (6:00 - 12:00) (18:00 - 24:00)	METOP-1 METOP-2 METOP-3 METEOR 3M-1 METEOR 3M-2 RESURS 01-4	EUMETSAT EUMETSAT EUMETSAT Russia Russia Russia	2003 2007 2010 8/1999 1998	(827 km) (9:30) (827 km) (9:30) (827 km) (9:30) (9:15) (TBD) partly meteorological mission
Sun-synchr. "Afternoon" (12:00 - 16:00) (00:00 - 04:00)	NOAA-L NOAA-M NOAA-N NOAA-N' NPOESS-1 NPOESS-3	USA/NOAA USA/NOAA USA/NOAA USA/NOAA USA/NOAA USA/NOAA	12/1999 04/2001 12/2003 07/2007 2008 2013	(13.30) (13:30) (13.30) (13.30) (13:30) (13.30)
Sun-synchr. "Early morning" (4:00 - 6:00) (16:00 - 18:00)	DMSP-S15 DMSP-S16 DMSP-S17 DMSP-S18 DMSP-S19 DMSP-S20 NPOESS-2 NPOESS-4	USA/NOAA USA/NOAA USA/NOAA USA/NOAA USA/NOAA USA/NOAA USA/NOAA USA/NOAA	1999 2001 2002 2003 2005 2007 2010 2016	
Non sun-Synchronous or unspecified orbits	FY-1 C FY-1 D	China China	1999 2001	

USA-WP-04 recalled the US plan for polar satellites, within the context of national cooperation with NASA and DOD and international cooperation with EUMETSAT. Following the launch of NOAA-15, the remaining satellites of this generation will include NOAA-L, -M, -N, -N'. It was noted that NOAA-15's imager, AVHRR/3 has a 6th channel, called 3A, operated in time-sharing with current Channel 3. NOAA-N and -N' will have a common core payload with Metop-1 and 2. The future generation, called NPOESS, will provide continuity for both the POES and DMSP missions. It is planned to permanently include two operational satellites, one at 5:30 hrs and one at 13:30 hrs local solar time (LST), to be complemented by one EUMETSAT provided Metop satellite at 9:30 hrs LST.

Attention was drawn by the USA (USA-WP-05) to the new S-band modulation scheme that has to be implemented on NOAA-N and NOAA-N' down-link HRPT transmission, in order to comply with ITU regulation on Power Flux Density.

Noting the global dimension of the HRPT Service, WMO stressed that such a change would require the provision of detailed information at an early stage to the world-wide user and manufacturer communities. CGMS noted important concerns that would justify a temporary postponement of NOAA compliance to the ITU regulations until the planned implementation of the LRPT and new ITU compliant HRPT.

ACTION 26.04 **WMO and CGMS satellite operators to express to the USA by 30 July 1998 their assessment of the difficulties anticipated for the global community resulting from the change of HRPT modulation scheme for NOAA-N and -N' and to support a decision by the USA to postpone implementation of the change until after NOAA-N.**

C.2 Future Geostationary Meteorological Satellite Systems

It was recalled (EUM-WP-04) that MSG will be a spin-stabilised satellite carrying as a main instrument the 12-channel spinning enhanced visible and infrared imager (SEVIRI). The main mission of MSG will be to acquire and disseminate multi-spectral imagery, air mass analysis and high-resolution imagery every 15 minutes. Additional missions of MSG include data collection, Search & Rescue relay and a global earth radiation experiment (GERB).

EUMETSAT informed the meeting that the MSG engineering model was being integrated, and that MSG-1, -2, -3 were planned for launch in 2000, 2003 and 2007, respectively. The flight models of SEVIRI and GERB instruments were expected to be available in early 1999 and meet required performances. Parallel operations of Meteosat-7 and MSG-1 are planned for three years, until 2003, to facilitate the transition of users to the new satellite system. Table 6 summarises the overall mission objectives of MSG.

TABLE 6: OVERVIEW OF MSG MISSION OBJECTIVES

Mission	**Characteristics**	**Note**
Imaging For basic imagery, airmass analysis and high-resolution imagery	Channel — Spectral band/Radiometry HRV — Broad Vis.* SNR>4.3 @ 4.59 $Wm^{-2}sr^{-1}\mu m^{-1}$ VIS0.6 — 0.56-0.71 SNR>10.1 @ 5.33 $Wm^{-2}sr^{-1}\mu m^{-1}$ VIS0.8 — 0.74-0.88 SNR>7.28 @ 3.57 $Wm^{-2}sr^{-1}\mu m^{-1}$ IR1.6 — 1.50-1.78 SNR>3 @ 0.75 $Wm^{-2}sr^{-1}\mu m^{-1}$ IR3.9 — 3.48-4.36 0.35 K @ 300 K WV6.2 — 5.35-7.15 0.75 K @ 250 K WV7.3 — 6.85-7.85 0.75 K @ 250 K IR8.7 — 8.30-9.10 0.28 K @ 300 K IR9.7 — 9.38-9.94 1.50 K @ 255 K IR10.8 — 9.80-11.80 0.25 K @ 300 K IR12.0 — 11.00-13.00 0.37 K @ 300 K IR13.4 — 12.40-14.40 1.80 K @ 270 K	
	Imaging area Visible and infra-red channels: Full earth disc from geostationary orbit High-resolution visible: full North-South scan of earth disc; (adjustable) half earth disc in East-West	
	Sampling distance (at sub-satellite point) Visible channels: 3 km Infra-red channels: 3 km High-resolution visible: 1 km	
	Image repeat cycle 15 minutes full earth disc	
Data Dissemination	High Rate Information Transmission (HRIT) 1000 kbps of full image data, products, DCP and foreign satellite data etc.; lossless compression envisaged; encryption possible Reception with dedicated user station of minimum 12 dB/K Low Rate Information Transmission (LRIT) 128 kbps of reduced image data, products, DCP and foreign satellite data etc.; lossy compression envisaged; encryption possible Reception with dedicated user station of minimum 5 dB/K	
Data Collection	210 regional channels (high band) 40 international channels up to 210 regional channels in the band of neighbouring satellite systems (as contingency; low band)	Received and processed Received and processed Satellite relay only
Product Extraction	Key products extracted centrally, e.g. - Atmospheric Motion Vectors (AMV) - Cloud Analysis (CLA) - Cloud Top Height (CTH)	Further products developed and extracted in de-central facilities
Secondary Payloads	Scientific GERB instrument: Global earth radiation coverage in three bands every 2.5 min; full data set to noise spec. every 15 min; GEOSAR message relay: Reception of distress signals at 406 MHz from most of the earth disc and downlink on 1544.5 MHz	Accommodation approved Accommodation approved

The distributed elements of the ground segment of MSG and EPS, explained in (EUM-WP-05), will include 7 Satellite Application Facilities (SAF) dedicated to various product development and application areas. The SAFs for Nowcasting and Very Short-term Forecasting, Ocean and Sea Ice, and Ozone Monitoring will be completed in 2002. The SAFs for Climate Monitoring, NWP, GRAS Meteorology and Land Surface Analysis are planned to be completed in 2003. WMO congratulated EUMETSAT for this promising user-oriented approach.

India (IND-WP-01) is planning to launch INSAT-2E in November 1998, INSAT-3A by the end of 1999, and INSAT-3D by 2002. INSAT-2E to be located at 83° E and INSAT-2E will fly a VHRR imager including a Water Vapour channel with 8 km horizontal resolution, as well as a high resolution CCD camera.

In JAPAN-WP-03 Japan presented the status of preparation of MTSAT. It is planned to launch it in August 1999, to be operated from March 2000 at 140° E. MTSAT meteorological data dissemination will rely on LRIT and HiRID, however WEFAX will be continued for 3 years in order to facilitate users transition to LRIT. The MTSAT dissemination frequency plan was provided. MTSAT imager characteristics are described in the table below:

Channel	VIS	IR1	IR2	IR3	IR4
Wavelength (μm)	0.55-0.80	10.3-11.3	11.5-12.5	6.5-7.0	3.5-4.0
Resolution	1 km (VIS), 4 km (IR) at sub-satellite point				
Quantization	10 bits for both VIS and IR channels (1024 gradations)				

TABLE 7: MTSAT IMAGER CHARACTERISTICS

Japan also presented its preparation for MTSAT-2, which is planned to be launched in 2004.

China informed CGMS (PRC-WP-04) that FY-2B is planned for launch in 2000. Compared to FY-2A, there will be no great change except for the corrections of the defects experienced on FY-2A.

Russia (RUS-WP-04) indicated that GOMS-1 had already exceeded its specified lifetime, but that GOMS-2 will not be launched before 2000.

The USA, in USA-WP-06, reported on its plan to launch GOES-M in 2002. It will include a Solar X-ray Imager (SXI) and achieve an improved horizontal imager resolution in the 6.7μm WV band. GOES-N, -O, -P, -Q will follow, with improved resolution to 4 km SSP in all IR channels. New options for rapid scanning are being considered for the GOES-Q imager.

TABLE 8: FUTURE GEOSTATIONARY SATELLITES COORDINATED WITHIN CGMS

(as of July 1998)

Sector	Future additional satellites	Operator	Planned launch	(Planned location) Other remarks
EAST-PACIFIC (180°W-108°W)	GOES-L GOES-M GOES-N GOES-O	US/NOAA US/NOAA US/NOAA US/NOAA	06/1999 2002 2002 2005	135° W and 75° W
WEST-ATLANTIC (108°W-36°W)	GOES-P GOES-Q	US/NOAA US/NOAA	2007 2010	
EAST – ATLANTIC (36°W-36°E)	MSG-1 MSG-2 MSG-3	EUMETSAT EUMETSAT EUMETSAT	2000 2002 2006	0° 0° 0°
INDIAN OCEAN (36°E-108°E)	GOMS-N2 INSAT II-E INSAT III-A INSAT III-D FY-2B	RUSSIA INDIA INDIA INDIA CHINA	 1998 end 1999 2002 2000	76° E 83° E 105° E
WEST-PACIFIC (108°E- 180°E)	MTSAT-1 MTSAT-2	JAPAN JAPAN	08/1999 2004	Multi-functional Transport Satellite 140°E

D. OPERATIONAL CONTINUITY AND RELIABILITY

PRC-WP-05 and JAPAN-WP-04 reported that Japan and China had jointly evaluated the possibility of a contingency arrangement. From a technical point of view, GMS and FY-2 systems have a high level of compatibility with regard to area covered and transmission characteristics, however, long term contingency arrangements could only be considered if respective launch schedules allowed sufficient in-orbit redundancy.

CGMS congratulated PRC and Japan for the steps taken on this very important issue for the global community, and agreed to hold a Working Group session on Contingency Planning to review possibilities for further progress (see later Report of Working Group IV).

E. METEOROLOGICAL SATELLITES AS PART OF WMO PROGRAMMES

E.1 World Weather Watch

WMO-WP-05 introduced the WMO strategy to improve satellite system utilisation as summarised in Table 9. It highlighted its efforts in seeking potential funding sponsors to provide workstations and networks in developing countries and actions within the World Weather Watch to improve the performance of the MTN and the GTS to accommodate increasing flows of satellite data and products. WMO suggested that CGMS satellite operators consider the inclusion of data distribution through the use of a Data Distribution Service on board each geostationary satellite.

CGMS Members noted the comprehensive nature of the WMO strategy and agreed to consider what actions they could take to assist with implementation.

CGMS agreed to the following action:

ACTION 26.05 **CGMS satellite operators to inform WMO of the actions they propose to take in support of the WMO Strategy of Improved Satellite System Utilisation by April 1999.**

In response to CGMS ACTION 25.04, WMO introduced (WMO-WP-07) the Statement of Guidance on the Feasibility of Meeting WMO Requirements developed by the CBS Working Group on Satellites.

Its purpose is two-fold:
- to inform WMO Members on how their requirements will be met by satellite systems,
- to support a dialogue between WMO Members and satellite agencies on how to best meet the WMO requirements.

It is a 4-step process including the review of user requirements, the review of satellite observing capabilities, a compliance analysis of the capabilities vs. the requirements, and a Statement of Guidance based on this analysis. A preliminary conclusion is that, in the five application areas initially considered, there is a reaffirmed need for operational continuity of a suite of instruments deployed from at least two polar orbiting and at least five geostationary platforms.

Furthermore :

Global NWP will benefit from data provided by the polar orbiting sounding instruments (AMSU) and is awaiting high spectral resolution measurements from infrared interferometers (AIRS, IASI, CrIs) planned for the year 2000 and beyond. The measurement of wind profile still remains necessary, but is awaiting relevant technologies to mature.

TABLE 9: STRATEGY TO IMPROVE SATELLITE SYSTEM UTILISATION

STRATEGIC GOAL	MAJOR OBJECTIVES	PROJ	PROPOSED ACTION TOPICS
To improve systematically the utilisation of the GOS space-based sub-systems capabilities with emphasis on improving utilisation of satellite data and services in developing countries		BEN	Foster improved promotion of systems use at User Forum Favour multi-agency strategy promoting satellite system benefits Focus on improved warning and monitoring of environmental hazards such as severe weather, volcanic ash, air and ocean pollution etc.
	To focus on the needs of developing countries	DPD	Study the concept of specialised centres and networks to assist NMHSs in the use of satellite data, e.g., new applications, NWP products Promote better transfer from research to operational applications Focus in high identified priority user requirements for satellite applications Assure closer operational development links with PIs Implement operational distributed database system Study specifications for improved WMC/RSMC satellite products
	To improve the use of satellite data through increased capabilities in its applications by direct involvement of existing WMO Member expertise	E&T	Favour the implementation of specific satellite E&T programmes in RMTC' s and organization of other relevant WMO training activities Expand US-based virtual lab network in RA III & IV Focus on better use of polar –orbiting data and products
	To improve the access to satellite data through increased effectiveness in the distribution of satellite system data and products at major hubs- in particular those maintained by satellite operators, WMO WMC' s RSMC and other entities as appropriate	INF	Evaluate the status of aid projects (Swiss, Italian...) Seek CGMS help for assuring the continuity of Indian Ocean/RA II satellite coverage Propose major WMO project on low-cost satellite work station Promote the expansion of EUMETSAT MDD system use in RA I & II Focus on effective use of LRIT in RA II & V (w. MTSAT-1) Focus on a smooth transition from WEFAX/APT to LRIT/LRPT Focus initial funding on work station and networking Expand use of DCP/DRS for agriculture and Hydrology Pursue improved performance of the MTN and GTS to accommodate increasing flows of satellite data Promote a better use of Internet and systems such as VSAT
		RM	Continuously perform critical review process of satellite data availability and use linking monitoring to action plans Review WMO requirements for new Earth Observation Satellite data

Proposed action items are considered under the following project areas:

BEN	=	Improve benefits, mainly through promotion
DPD	=	Data processing and development of new methodologies
E&T	=	Education and Training;
INF TLC	=	Infrastructure, including receiving stations, DCP, MDD equipment etc. and
RM	=	Continuous review and monitoring activities

Current satellite systems are unable to simultaneously satisfy all user requirements for synoptic meteorology and nowcasting.

Hydrology is anticipating improvements in the estimates of snow cover, snow water equivalent and soil moisture from the experimental ADEOS II and EOS microwave instrument (AMSR). In addition, agricultural meteorology needs leaf area index and land cover measurements with higher spatial resolution.

All CGMS satellite operators welcomed the rigorous approach taken by WMO in developing the Statement of Guidance and found the Preliminary Statement very useful and highly relevant.

CGMS strongly encouraged WMO to continue with the further development of its rolling review process and Statement of Guidance, and made the following suggestions:

- It is important to obtain an authoritative formal statement from the WMO Congress, updated as necessary by the WMO Executive Council, in order to help satellite operators secure the necessary resources for future missions that will better support WMO requirements.

- There needs to be more emphasis on strategic requirements for the period 2008 to 2020. Most mission requirements in the 2000 to 2008 time frame are already almost fully committed because of the long lead-time required by satellite operators for system planning and procurement.

- There is a need for WMO to undertake some satellite data assimilation and impact studies to help with an analysis of benefits and costs.

ACTION 26.06 **WMO to continue the rolling review process to include additional applications of relevance to CGMS satellite operators and data impact studies and to present another iteration of the Statement of Guidance at CGMS-XXVII.**

WMO summarised (WMO-WP-14) the conclusions of the WMO/ESCAP Panel on Tropical Cyclones and the WMO RA-1 Tropical Cyclone Committee, stressing the essential role of satellite data coverage for tropical cyclone monitoring. WMO thanked China and EUMETSAT for their support to Indian Ocean coverage.

E.2 Other Programs

WMO reported (WMO-WP-13) on the activities of GCOS, a joint initiative of WMO, IOC of UNESCO, UNEP and ICSU, noting the creation of the Global Observation System Space Panel (GOSSP) which extends to GOOS and GTOS the objectives of the GCOS Space Panel.

Japan and EUMETSAT stated that the GOSSP should be encouraged to express a Statement of Guidance on requirements within its purview, similar to that provided by the Working Group on Satellites.

ACTION 26.07 **WMO to inform GCOS that CGMS suggested that GOSSP develop its own Statement of Guidance for requirements within their purview for consideration at a future CGMS.**

F. COORDINATION OF INTERNATIONAL DATA COLLECTION & DISTRIBUTION

F.1 Status and Problems of IDCS

F.1.1 Expansion of the IDCS

EUM-WP-07, presented a proposal for the planned use of the MSG DCP transponder, including an expansion of the IDCS from 33 to 40 channels (in response to CGMS ACTION 25.10). CGMS noted that the additional IDCS channels had to be selected in the middle of the frequency range. Members were invited to confirm their agreement with the proposed expansion and the schedule for the transition of DCP to the additional channels, resulting in the first allocation of international DCP from 1 January 2002.

Japan commented (JAPAN-WP-06) that if seven regional channels were re-allocated to the IDCS, this would require the re-allocation of several GMS DCP, which currently make use of these channels. This would also have an impact on the GMS ground data processing systems. CGMS decided to study the proposal further and to task the Working Group on Telecommunications to refine a proposal taking into account the constraints of all operators and the target date of January 2002.

F.1.2 Status of the IDCS

A status report on the IDCS was provided in EUM-WP-08 and JAPAN-WP-05.

EUMETSAT informed the meeting that, by special agreement with CGMS, channels I29-I33 inclusive were currently used within the Meteosat field of view in support of WMO programmes (mainly for agrometeorology and hydrology). EUMETSAT also indicated its intention to use, on a temporary basis, Meteosat-5 located at 63° E, in cooperation with Roshydromet, to support the Russian regional DCP mission of GOMS. With the agreement of CGMS, one additional IDCS channel would be used for this purpose and CGMS would be provided with full details in due course. All CGMS satellite operators agreed to this proposal.

CGMS was also informed that EUMETSAT had established a Web page containing the consolidated list of IDCS allocations. EUMETSAT expected that an interactive database (password controlled) would be implemented within a few months. Members would be kept informed of progress. This new scheme would allow IDCP operators to both allocate new DCPs and access their IDCP data.

Due to various planning difficulties, the IDCS end-to-end test was now postponed to 1-15 October 1998. ACTION 25.08 was thus updated with a new deadline.

Finally, CGMS Members were invited to provide any remaining comments and corrections relating to the draft revision of the IDCS Users Guide by end of August 1998.

ACTION 26.08	**CGMS Members to forward to EUMETSAT their final comments on the IDCS Users Guide by 31 August 1998.**

F.1.3 Interference

Interference affecting DCP channels was reported by China (PRC-WP-06), Japan (JAPAN-WP-07) and Russia (RUS-WP-06).

Japan reported that it had experienced increasing levels of interference affecting up to 30% of the operational channels, namely I1, I7, I8, I9.

Russia reported on the status of the dissemination of DCP messages via GOMS-Elektro. In 1997-1998 efforts were made to reduce (or remove) interference in the 401-403 MHz band. This has now been completed with the verification of the on-board and ground-based facilities of the GOMS-1 satellite network. Experiments have also been conducted with redesigned DCP operating at 1200 bps in order to reduce the impact of interference. Results from these experimental high data rate DCPs are promising.

CGMS was informed that the interference identified by China was identical to that experienced by Russia and probably had the same origin. Additionally, it affects the whole FY-2A DCP bandwidth. Russia and China wished to coordinate their efforts to cope with this problem.

ACTION 26.09	**Russian Federation and People's Republic of China to share their information and experience relevant to the interference on DCP channels in the GOMS and FY-2A areas of coverage.**

F.1.4 Higher Data Rate DCP

JAPAN-WP-18 described the use of DCP with higher data rates than 300 bps.

RUS-WP-07 presented some details concerning the development of a DCP relay system operating at 1200 bps. The theoretical studies and experiments carried out with modernised equipment demonstrate that the implementation of the 1200 bps DCP relay system results in practically full removal of the impact of interference affecting the 401-403 MHz frequency band.

F.2 Ships, including ASAP

WMO presented the latest status of the Automated Shipboard Aerological Programme (ASAP) in WMO-WP-15. In 1997 a total of 24 ASAP units were operated: Denmark (2 units), France (4 units), Germany (6 units), Japan (5 units), Russia (1 unit), Spain (1 unit), Sweden/Iceland (1 unit), the UK (2 units) and the USA (2 units). The total number of ASAP soundings in 1997 slightly decreased relative to 1996, and one part of this decrease can be attributed to the phase out of the OMEGA navigation system. However, the small amplitude of this decrease clearly shows that most operators have successfully performed the transition to GPS or other wind finding systems in due time.

F.3 ASDAR

In WMO-WP-10, CGMS was informed that within the ASDAR programme, which is under the guidance of the WMO Operating Consortium of ASDAR Participants (OCAP), 20 of the 23 ASDAR systems originally purchased have been installed on aircraft. Ten units are operational on aircraft belonging to British Airways, three on KLM aircraft, two each on aircraft operated by Air Mauritius and South African Airways, and one each on aircraft operated by SAUDIA, Lufthansa and Aerolineas Argentinas. The ASDAR systems provide one observation every seven minutes at the cruise phase of flight and observations are also made at selected pressure levels during ascent and descent.

G. COORDINATION OF DATA DISSEMINATION

G.1 Dissemination of Images via Satellite

Russia (RUS-WP-05) informed CGMS that the dissemination of infrared images in WEFAX format via GOMS-Elektro has been suspended in February 1998. On a provisional basis, WEFAX-type images are made available via Internet on a 3-hourly basis, within one hour of acquisition. IR image data had been regularly relayed to EUMETSAT via a dedicated telephone link eight times per day.

EUMETSAT introduced document EUM-WP-28, which presented the current status of the "LRIT/HRIT Global Specifications" as well as the "MSG Mission Specific Implementation". The document provided information on minor modifications to the formats, which were required to cope with shortcomings detected during implementation of these formats for MSG (EUMETSAT) and MTSAT (JMA). The proposed changes had been discussed and agreed between these organisations. All modifications were reflected in "version 2.5 Draft A" of the "LRIT/HRIT Global

Specifications", which were attached to EUM-WP-28. CGMS Members were invited to approve this new issue of Global Specifications.

The document also addressed the initiative of WMO to define a standard format for image data transmission via other media than satellite broadcasts and proposed to consider the use of LRIT/HRIT formats for such transmissions.

ACTION 26.10 **USA to forward its final comments on LRIT Global Specification Issue 2.5 to the Secretariat by 31 July 1998.**

CGMS agreed that, subject to the comments of the USA under the action above, this version of the LRIT Global Specification would become the CGMS standard. WMO stated with appreciation that the adoption of this LRIT standard was a major milestone for CGMS, adding that the format shall also be considered for data exchange via other media.

Japan (JAPAN-WP-09) confirmed the implementation of LRIT on MTSAT in 2000. MTSAT LRIT will disseminate digital cloud images, meteorological observation data and numerical weather predictions. Cloud imagery will not be encrypted, however, other meteorological information will be encrypted and the relevant decryption code will be provided to WMO Members upon request in accordance with JMA data policy.

China submitted (PRC-WP-07) a detailed description of the transmission characteristics of the S-VISSR Data Dissemination from FY-2A and FY-2B.

EUMETSAT (EUM-WP-09) introduced the draft LRPT/AHRPT global specification as revised after the special meeting on this subject, which was held on 9-10 December 1997 in Washington. This meeting was attended by experts from EUMETSAT, NOAA, NASA, ESA and WMO. EUMETSAT recalled the need to agree on an internationally coordinated system in view of the global use of polar-orbiting satellites. EUMETSAT stressed that the global specification must be frozen shortly, with regard to the development schedule of Metop and Meteor 3-M and to the lead-time necessary for the user community. It was proposed and agreed that the new "advanced" HRPT would be named AHRPT.

With regard to this draft LRPT/AHRPT specification, USA recalled (USA-WP-10) the initial developments and difficulties encountered in defining and implementing a common format and confirmed its support for this joint achievement, thus proposing to adopt the LRPT/AHRPT global specification as a standard.

Russia, bearing in mind the forthcoming implementation of HRPT on Meteor-3M, agreed to forward its final comments on this matter by the end of August 1998. India also wished to review the specifications in detail. PRC has no difficulty with LRPT and will review CHRPT in the light of AHRPT. WMO stressed the need to converge to a single format.

ACTION 26.11 **Russia and India to forward to the Secretariat by 31 August 1998 their final comments on the proposed LRPT/AHRPT specifications.**

CGMS agreed that, subject to the comments to be forwarded under the above action, the proposed LRPT/AHRPT specification shall be adopted as the CGMS standard for future Direct Broadcast Services from Polar Orbiting Satellites. It was clarified that, with the adoption of this standard, each satellite operator will provide its best efforts to implement this standard taking into account its programme constraints.

WMO-WP-3 described the status of WMO's activities related to the conversion of the APT/WEFAX services from analogue to digital and scheduled to occur at the end of the decade. In anticipating the conversion and its corresponding impact on its Members, WMO initiated a LRIT/LRPT project within its Secretariat that will address three specific aspects of the conversion. The first aspect to be covered will be the transition period, its duration and regional application. The second aspect will address the modification or replacement of the existing ground receiving stations. This aspect will be accomplished in concert with CGMS satellite operators and equipment manufacturers. Finally, improved capabilities through increased awareness of the potentialities for the new data will be presented to potential users. In order to assist WMO with regard to the conversion, CGMS Members provided the latest status for their missions as recorded in Tables 10 and 11.

CGMS also noted that the third session of the CBS Working Group on Satellites had finalised the "Application and Presentation Layer Specifications for LRIT/LRPT/HRIT/HRPT Data Format" previously submitted for review to CGMS XXV. An additional section describing the attributes of the analogue to digital transition was added. The section was entitled "Questions and Answers regarding the Transition of the Meteorological Satellite Data Direct Broadcast from Analogue to Digital". The Specifications will be published as a WMO Satellite Activities Technical Document. Tables 12 and 13 contain a summary of the WMO Application and Presentation Layer Specifications for the LRIT/LRPT/ HRIT/HRPT Data Formats.

EUMETSAT noted (EUM-WP-29) its input provided to WMO in the consideration of Application/Presentation Layer Specifications for new data formats indicating the current baseline of the MSG dissemination scheme.

EUMETSAT proposed (EUM-WP-10) that a Broadcast Format Guide should be developed, noting however that this would require a careful documentation control. There was a general agreement on this proposal and EUMETSAT agreed to take the lead for this document, with inputs provided by all CGMS Members.

ACTION 26.12 **EUMETSAT to propose an outline of a Broadcast Format Guide to be developed with inputs from all CGMS Members, by 30 September 1998.**

ACTION 26.13 **CGMS Members to indicate points of contact and provide input to the Broadcast Format Guide by 1 January 1999.**

TABLE 10: STATUS FOR LRIT CONVERSION, SATELLITES IN GEOSTATIONARY ORBIT

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	09/1997	WEFAX	07/97	12/2003
	MSG 1	10/2000	LRIT	12/00	2003
	MSG 2	2002	LRIT	2003	2008
	MSG 3	2007	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		
Japan	GMS-4	09/1989	WEFAX	12/89	06/1995
	GMS-5	03/1995	WEFAX	06/95	
	MTSAT-1	08/1999	WEFAX LRIT	03/00 03/00	03/2003
USA	GOES – 8	04/1994	WEFAX	11/94	
	GOES – 9	05/1995	WEFAX	01/96	
	GOES – K	04/1997	WEFAX	06/97	
	GOES – L	07/2002	WEFAX	09/02	
	GOES – M	08/2000	WEFAX	10/00	
	GOES – N	2002	WEFAX/LRIT		
	GOES – O	2005	WEFAX/LRIT		
Russian Federation	Elektro-1	11/94	WEFAX		
	Elektro-2	---	WEFAX		
China	FY-2	---	WEFAX		

TABLE 11: STATUS FOR LRPT CONVERSION, SATELLITES IN POLAR ORBIT

Operator	Satellite	Launch (M/Y)	Service	Start	Stop
EUMETSAT	Metop-1	2002	LRPT	2002	
	Metop-2	2007	LRPT	2007	
	Metop-3	2012	LRPT	2012	
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-K	08/1997	APT	08/97	
	NOAA-L	12/1999	APT	12/99	
	NOAA-M	04/2001	APT	04/01	
	NOAA-N	12/2003	APT	12/03	
	NOAA-N'	07/2007	APT	07/07	
	NPOESS-1	07/2009	LRPT	07/09	
	NPOESS-2	10/2010	LRPT	10/10	
China	FY-1 C	---	None		
	FY-1 D	---	None		
Russian Federation	Meteor 2-21	08/1993	APT	08/93	
	Meteor 3-5	08/1991	APT	08/91	
	Resourse-01-N4	----	APT		
	Meteor 3M-1	----	APT		
	Meteor 3M-2	2002	LRPT	2002	

TABLE 12 AND TABLE 13 (PAGE 31): APPLICATION AND PRESENTATION LAYER SPECIFICATIONS FOR LRIT/LRPT/HRIT/HRPT FORMAT

LOW RATE					
	Geostationary	**Polar**		**Geostationary**	**Polar**
Application Layer	LRIT Imager data display – Navigation - Calibration - Remapping - Enhancement - Simple image processing (filtering, +, -, x, /, etc.) - Zooming - Single image or multiple image display - Looping and zoomed looping Sounder data display - Plotting - Contour - Sounder image display - Objective analysis to form grid values Numerical products grid data display - Plotting - Contour Meteorological observation display - Plotting - Thermodynamic display - Cross-section - Stability index calculation and display - Objective analysis to produce grid values Overlap display - Image with sounding - Image with grid data - Image with meteorological observation Administrative message display - Message text display - Message display in tables - Message display in graphics	LRPT Imager data display - Navigation - Calibration - Remapping - Enhancement - Simple image processing (filtering, +, -, /, etc.) - Zooming - Single image or multiple image display - Looping and zoomed looping Sounder data display - Plotting - Contour - Sounder image display - Objective analysis to form grid values Administrative message display - Message text display - Message display in tables - Message display	Presentation Layer	LRIT - Imageries/Channel selection: 5 channels in following priority order: - Infrared window channel 11,0 µm - Visible channel 0.6 µm - Water Vapour channel 6.8 µm - Infrared channel 3.7 µm - Infrared Split window channel 12.0 µm Horizontal resolution: - Full IR horizontal resolution Image frequency: - Half-hourly plus at least 15 images every 3 hrs from other polar and/or geostationary satellites Dynamic range: - 8 bits (256 grades) Sounders - Infrared sounder - Microwave Temperature Sounder - Microwave Humidity Sounder - Ozone sounder - GPS sounder Retransmission of other satellite data - Low resolution imager or sounder data from other polar or geostationary meteorological satellites Products from meteorological satellites - Topical cyclone location and intensity - Volcanic ash detection - Cloud type analysis - Sea surface temperature Numerical prediction products: Height, Temperature, Humidity, Wind Meteorological observation - Surface weather (including ship) reports - Upper-air sounding (including ship) reports - Aircraft reports - Data collection platform reports Satellite administrative message - Observation schedule - Navigation information - Calibration information - Satellite performance information - Space environment monitoring data	LRPT Imageries Channel selection: 5 channels in the Following priority order: - Infrared window channel 11.0 µm - Visible channel 0.6 µm - Near infrared channel 0.8 µm - Infrared channel 3.7 µm - Infrared split window channel 12.0 µ Horizontal resolution: - Smoother horizontal resolution image with 4 Km or better Image frequency: - 2 paths a day per satellite (i.e. 12-hourly intervals) Dynamic range: - 8 bits (256 grades) Sounders - Infrared sounder - Microwave temperature sounder - Microwave humidity sounder - Ozone sounder - GPS sounder Other instrument data - Local electric fields - Space environment monitoring - Data collection system - Search & rescue Satellite administrative message - Orbital parameters - Telemetry - Spacecraft ephemeris - Attitude and timing data - Other administrative message

HIGH RATE					
	Geostationary	**Polar**		**Geostationary**	**Polar**
Application Layer	HRIT / Imager data display - Navigation - Calibration - Remapping - Enhancement - Simple image processing (filtering, +, -, x, /,etc.) - Zooming - Single image or multiple image display - Looping and zoomed looping Sounder data display - Plotting, - Contour Sounder image display - Objective analysis to produce grid values. Numerical products grid data display - Plotting, - Contour Meteorological observation display - Plotting - Thermodynamic display - Cross section - Stability index calculation and display - Objective analysis to form grid values Overlap display - Image with sounding - Image with grid data - Image with meteorological observation Products - Tropical cyclone location, intensity & movement - Volcanic ash detection - Cloud motion and water vapour winds - Fog and low cloud detection - Cloud type analysis - SST and LST - Outgoing long-wave radiation - Solar irradiance - Total ozone monitoring - Upper troposphere humidity - Precipitation estimation - Temperature and moisture soundings Administrative message display - Message text display - Message display in tables - Message display in graphics	HRPT Imager data display - Navigation - Calibration - Remapping - Enhancement Simple image processing (filtering, +, -, x, /, etc.) - Zooming - Single image or multiple image display - Looping and zoomed looping Sounder data retrieval and display - Sounder data retrieval - Plotting - Contour - Sounder image display - Objective analysis to form grid values. Products development - Tropical cyclone location, intensity and movement - Forest fire detection - Volcanic ash detection - Local sounding - Fog and low cloud detection - Cloud type analysis - NDVI - SST and LST - Outgoing long-wave radiation - Total ozone monitoring Administrative message display - Message text display - Message display in tables - Message display in graphics	Presentation layer	HRIT Images - All channels - Full horizontal resolution - Full time frequency - Full dynamical range Sounders All sounder data including - Infrared sounder - Microwave Temperature Sounder - Microwave Humidity Sounder - Ozone sounder - GPS sounder - Infrared atmospheric sounder interferometer - Advanced scatterometer Other Instrument data - Space environment monitoring - Data collection system - Search & rescue Satellite administrative message - Observation schedule - Navigation information - Calibration information - Satellite performance information	HRPT Images - All channels - Full horizontal resolution - Full time frequency - Full dynamical range Sounders All sounder data including - Infrared sounder - Microwave Temperature Sounder - Microwave Humidity Sounder - Ozone sounder - GPS sounder - Infrared atmospheric sounder interferometer - Advanced scatterometer Other instrument data - Local electric fields - Space environment monitoring - Data collection system - Search & rescue - GPS position Satellite administrative message - Orbital parameters - Telemetry - Spacecraft ephemeris - Attitude and timing data - Other administrative message

G.2 Dissemination of Products via GTS or Other Means

In RUS-WP-08 Russia provided some examples of WEFAX-type imagery disseminated via the Internet. It is planned to develop the CGMS dissemination system by placing additional images, data and products on the server. The Internet server http://sputnik.infospace.ru provides free access to reduced image data from Russian operational satellites, as well as to data catalogues and information relating to Russian operational space systems.

In WMO WP-11, WMO noted that a set of amendments to improve the identification of instruments flown aboard meteorological satellites had been proposed to the WMO Commission for Basic Systems (CBS) Working Group on Data Management/Sub-group on Data Representation. The Sub-group approved part of the proposed changes, but rejected the modification of Code Forms SATEM, SARAD and SATEM to include an identifier I3I3I3 for the instrument. The rejection was reached due to the lack of a requirement for this change of the code forms. Some CGMS Members were of the opinion that there was a strong need for the identifier and agreed that WMO should consider the proposed modifications to the SATEM, SARAD and SATOB Codes with a view to their adoption by the CBS Working Group on Data Management and then CBS XII in 2000 for their eventual implementation in November 2001.

ACTION 26.14 **WMO to inform the relevant CBS Working Group of the requirement of some members of CGMS for a common code table to identify a particular instrument for satellite data and products.**

G.3 Global Exchange of Satellite Image Data via Satellite or via the GTS

JAPAN-WP-10 reported on the status of exchange of digital satellite image data between satellite operators, using GTS lines and satellite relay. JMA also announced its intention to convene a meeting on the promotion of satellite data exchange and utilisation in the Pacific Region.

WMO-WP-9 noted that the space-based subsystem of the Global Observing System (GOS) was entering a period of major technological change with the imminent launch of a new generation of satellites, advanced new instruments and the transition from analogue to digital broadcast services. Of particular concern was the explosive growth in the volume of satellite data that will become available beyond 2000. In recognising the importance for distribution of satellite data and products by both direct broadcast and over the GTS, WMO described its requirement for digital satellite image data and extracted product exchange over the GTS, as well as through the direct broadcast provided by meteorological satellite systems. In response to the WMO requirements for satellite data over the GTS as well as by direct broadcast, CGMS satellite operators noted that for the present their data would be distributed by direct broadcast. However, CGMS satellite operators noted the continuing growth of data distribution by other means including Internet and asked WMO to consider studying distribution systems for future satellite systems to include direct broadcast, the GTS, Intranets and/or combinations thereof with a view towards making recommendations.

ACTION 26.15 **WMO to initiate a study on the possibilities of meeting WMO requirements for digital satellite image data exchange, taking into account the future trends in communication technology.**

H. OTHER ITEMS OF INTEREST

H.1 Application of Meteorological Satellite Data for Environment Monitoring

The USA reported (USA-WP-11) on the use of operational altimeter data for ocean monitoring. Topex/Poseidon (T/P) altimeter satellite, launched in 1992 as a research mission of the US and French space agencies, has become an integral part of NOAA's satellite system for monitoring the oceans. Operational use of altimeter data began in 1997 just prior to the recent El Nino event. The altimeter data are assimilated in coupled ocean-atmosphere models and improved both the ocean initial conditions and the sea surface temperature forecasts with lead times of up to 6 months. The USA informed CGMS that further altimeter data will be available over the next decade from the GEOSAT Follow-on, and later from Envisat and Jason-1 missions. CGMS thanked the USA for offering to serve as the point of contact for users interested in GEOSAT altimeter data. CGMS also expressed interest for more information on the Envisat altimeter mission of ESA. ESA recalled that ERS-1 and ERS-2 had both carried altimeter instruments and accepted with pleasure an invitation to present the status of Envisat at CGMS XXVII.

ACTION 26.16 **EUMETSAT to invite ESA to report at CGMS XXVII on the status of the Envisat mission.**

H.2 Search and Rescue

CGMS noted that no issue was raised under this agenda item.

H.3 Meteorological Data Distribution via Satellite

The USA gave a verbal report on the Emergency Managers Weather Information Network (EMWIN), a broadcast system, which provides information on severe weather, other environmental hazards, or routine weather data. Data are originating from Weather Offices, selected along priority criteria, relayed by GOES-8, GOES-9 and Galaxy-4 satellites and can be received with small dish receivers by emergency managers, fire departments, and other civilian or military governmental agencies.

H.4 Training

WMO introduced its Education and Training Strategy (WMO-WP-06) as reviewed by the April 1998 meeting of the CBS Working Group on Satellites. WMO noted with particular appreciation the efforts provided by the USA in Regional Association (RA)

III and IV and by EUMETSAT in RA I and VI. It encouraged the operators of geostationary satellites over RA II and RA V to develop some form of co-sponsorship of Regional Training Centres with satellite specialisation. WMO clarified that co-sponsorship does not necessarily imply establishing new training facilities, but rather enhancing existing facilities and available expertise.

In response to WMO, India and China expressed a strong interest in the further development of the WMO Education and Training Strategy. Japan notified CGMS of its intention to host some training events but needed more information on the scope and purpose of co-sponsorship arrangements in RA V before making any further commitment.

China informed CGMS that a one-month course on satellite data applications would be held in Beijing in cooperation with WMO and that another satellite applications course was being organised with ESCAP.

India confirmed the importance of training and recalled the role of the CSSTE-AP Training Centre affiliated to the United Nations, based in Dehradum/Ahmedabad.

Japan presented in JAPAN-WP-11 the current status and future plans for the development of Computer Aided Learning systems at the MSC, and provided a demonstration. Nephanalysis techniques are introduced through case studies based on a range of selected weather situations, including typhoons.

EUMETSAT reported in (EUM-WP-11) on its training activities carried out over the last year and outlined its plan for the coming years. In line with the WMO training strategy, training sessions are being organised in several Member States, in some Central and East European countries, as well as in two Regional Training Centres in Africa, Niamey and Nairobi. An important component of the training strategy is the development of Computer Aided Learning (CAL) modules through various cooperative projects (EuroMet, Satrep, ASMET). It is planned to further develop CAL modules, to organise on-site workshops addressing the use of current Meteosat data and new events to prepare users for the transition to MSG and EPS data, products and applications. The sponsoring of a few graduate fellowships is also envisaged.

H.5 Information

Noting the need for an up-to-date reference document on CGMS activities the CGMS Secretariat submitted a proposal (EUM-WP-06) to review the structure and content of the CGMS Consolidated Report. It was proposed to prepare a new version focussing on common CGMS achievements and agreed CGMS practices. The new Consolidated Report would avoid the duplication of information provided by each Member on its own activities or systems, but rather make reference to e.g. the home pages or the publications issued by the Members. The Secretariat proposed an outline for the new Consolidated Report and suggested constituting a drafting committee who would implement this proposal. It was further proposed that each section, once completed and validated, would be made available on-line via the CGMS home page maintained by WMO.

The CGMS Members welcomed this proposal and agreed to contribute to its implementation, coordination being ensured by the Secretariat and WMO. It was noted that information comprising this Report should be updated at least once a year.

ACTION 26.17 **CGMS Members to nominate a point of contact to contribute to the development of the new CGMS Consolidated Report, by 31 August 1998.**

EUM-WP-15 briefly described the content of the EUMETSAT Web pages. EUMETSAT also gave a status report (EUM-WP-22) on the U-MARF development. EUMETSAT confirmed that all CGMS Members would have easy access to its archive. Furthermore it thanked the USA for sharing its experience on the Satellite Active Archive (SAA). Based on its experience of the SAA, the USA underlined the value of user consultation statistics.

EUMETSAT reported (EUM-WP-12) on the conferences and publications which had taken place since CGMS XXV, namely the Meteorological Satellite Data Users' Conference (Brussels, 1997), the second EUMETSAT Eastern and Central European Forum, (Prague, March 1998) and the ninth Conference on Satellite Meteorology and Oceanography (Paris, May 998). It indicated its plan to convene the third EUMETSAT User Forum in Africa (Rabat, September 1998), the fourth Winds Workshop (Saanenmöser, October 1998), the next Data Users Conferences (Copenhagen, 1999 and Bologna, Italy in 2000) and the CEOS Plenary (Sweden, 1999).

EUMETSAT gave a brief account of the progress with the CGMS Directory of Meteorological Satellite Applications (EUM-WP-13), the first issue of which was published in May 1998. This first issue contained 64 topics out of the 130, which are considered for the complete version. CGMS Members were encouraged to submit further topics for inclusion in the next release of the document. CGMS thanked EUMETSAT for pursuing this action, agreed to further contribute and were pleased to accept EUMETSAT's offer to continue and maintain this document in the future. CGMS Members also suggested that parts of the document should be made available on the CGMS home page.

ACTION 26.18 **CGMS Members to forward to J. Morgan by 31 August 1998 their inputs to the second release of the CGMS Directory of Meteorological Satellite Applications.**

The CGMS Secretariat informed the meeting on the third United Nations Space Conference (UNISPACE III) to be held at the UN Office in Vienna, Austria, on 9-19 July 1999 (EUM-WP-18). After consultation with the UN Office of Outer Space Affairs, the CGMS Secretariat submitted a proposal to organise, in the context of UNISPACE III, a dedicated half-day "CGMS Workshop" which would have the following objectives:

- to publicise the capabilities of the current and planned meteorological satellites
- to highlight the usefulness of these systems in support of global issues
- to highlight the international cooperation which makes this global system possible.

WMO pointed out that GCOS and CEOS issues will also be addressed at UNISPACE III. CGMS Members thanked EUMETSAT for the initiative and declared their support and readiness to participate.

ACTION 26.19 EUMETSAT to coordinate with UN-OOSA participation of CGMS in UNISPACE III.

In WMO-WP-1, WMO described its database containing information related to satellite receiving stations and provided each Member with an electronic copy of this database. The data were received from many sources including CGMS satellite operators. However, it was noted that most CGMS satellite operators also maintain their own database. Each database was sufficiently different to preclude easy use by another CGMS Member as there were no common identifiers. Therefore, CGMS endorsed the use of the WMO database as a CGMS-wide database noting that it had an identifier common to all individual CGMS databases. In this fashion, each CGMS Member could maintain their database knowing that a unique identifier would be assigned in the CGMS-wide database such that duplicate information could easily be identified.

All CGMS satellite operators thanked WMO for maintaining this valuable tool which is a useful background information source for addressing many important issues such as frequency allocation or preparing users for new satellite systems. Where possible, CGMS agreed to conform to the proposed database file structure within individual databases.

WMO described (WMO-WP-8) its publications issued or in preparation since the last meeting of CGMS. In addition, CGMS noted that WMO would be making a request for an update to WMO Publication No. 411 to CGMS satellite operators during 1998 and that the information contained in the revised publication would also be made available via the CGMS home pages. Japan stressed that the calls for input should be sent well in advance of the need date.

WMO informed CGMS of the status of list-servers and CGMS and WMO Satellite Activities home pages in WMO WP-4. It noted that the CGMS home pages provided high visibility for CGMS, as well as providing a mechanism for updating of CGMS-wide documents. It also noted the need for maintaining current information on the home pages. It, therefore, agreed to develop an update mechanism for status information maintained on the WMO Satellite Activities home pages as well as on the CGMS home pages. CGMS Members expressed their gratitude to WMO for this valuable information tool and wished to assist WMO in providing input in a timely and accurate fashion.

H.6 Any Other Business

EUM-WP-26 described procedures followed to ensure compliance of the satellite operations system with the year 2000 transition. It presented a current status of activities and planned tests. The procedures involve an inventory and audit check, an assessment phase, the necessary transformation or upgrade of systems and, finally, a testing phase, involving the users. CGMS took note of the schedule of activities and details of forthcoming tests.

The USA, Japan, India, China and Russia also reported briefly on their activities addressing system Year 2000 compliance. The USA was confident that POES operations would not be affected and reported that tests were being conducted on the GOES systems. WMO reported that its Executive Council had sought assurance from CGMS that the satellite systems would be Year 2000 compliant. It was pointed out that the transition to the Year 2000 would be during the typhoon season on the southern hemisphere. The following two actions were agreed:

ACTION 26.20 **CGMS satellite operators to inform WMO of past and planned tests of Year 2000 compliance for communication to WMO Members via the WWW Newsletter.**

ACTION 26.21 **CGMS representative to make a presentation at CBS on behalf of CGMS on its Members' plans addressing Year 2000 compliance of their operational satellite systems.**

The USA informed CGMS (USA-WP-12) on the new US regulations for space-based Data Collection Systems that operate on NOAA's geostationary and polar-orbiting environmental satellites, whereby the use of these DCS will no longer be authorised where there are commercial space-based services available that meet user requirements. CGMS was pleased to receive confirmation that this would not affect the US contribution to the IDCS.

The USA also circulated to CGMS the Second Draft of the 300/1200 bps GOES DCP certification standard, and described in USA-WP-13, in response to CGMS ACTION 24.11. CGMS thanked the USA for this useful information. Clarifications were brought on the DCP random reporting mode and the measures taken to accommodate the relay of these messages. CGMS noted that such a random reporting (or "alert") mode was also compatible with that used on Meteosat and GMS satellites.

WMO asked CGMS Members to comment on a proposal described in WMO-WP-16 for restructuring the WMO Commission for Basic Systems, which will be considered at CBS Ext.98 in October 1998.

EUMETSAT noted that there were some satellite activities of an operational and technical nature that could be adequately handled by the proposed restructuring and that it was also important to work towards the integration of satellite and in-situ observations. Nevertheless, EUMETSAT was strongly of the view that the CBS restructuring proposal did not provide an appropriate level of identification of a focal point within WMO. Such a focal point is necessary to provide high level policy decisions and statements of requirements to the satellite operators who are presently spending in excess of $4 million US per day on global observation systems used extensively by WMO Members.

Although the other CGMS satellite operators were not yet in a position to comment formally on the CBS restructuring proposal, they were already inclined to take the view that it was important to have an identifiable entity with which they could clearly associate satellite activities within WMO.

In conclusion, CGMS satellite operators felt it appropriate to forward their views to WMO and agreed to the following actions:

ACTION 26.22	**All CGMS satellite operators to express to EUMETSAT their position regarding CGMS views on CBS restructuring, by 30 September 1998.**
ACTION 26.23	**EUMETSAT to forward to the President of WMO, by 15 November 1998 an agreed response by CGMS Satellite Operators to the CBS restructuring proposal, with respect to satellite activities and cooperation with CGMS.**

WMO suggested that for future CGMS meetings, the working papers should be circulated in electronic form and offered to make the WMO Satellite Activities server available for this distribution with password protection similar to that employed for the CBS Working Group on Satellites. All CGMS Members welcomed this proposal, thanked WMO for its assistance and agreed to distribute their working papers in Microsoft Office 97 Word format. This should replace the mail distribution of hard copies. The following actions were agreed:

ACTION 26.24	**WMO to inform the other CGMS Members on the detailed Procedure to be followed for placing working papers on the WMO Satellite Activities server.**
ACTION 26.25	**CGMS Members to distribute their working papers for CGMS XXVII in electronic form via the WMO Satellite Activities server.**

PARALLEL WORKING GROUP SESSIONS

REPORT FROM WORKING GROUP I: TELECOMMUNICATIONS

I/0 Introduction

Mr. Robert Wolf (EUMETSAT) was elected as Chairman of Working Group I on Telecommunications with Mr. Gordon Bridge (EUMETSAT) and Mr. Carl Staton (NOAA) as Rapporteurs. The Working Group comprised representatives of the satellite operators EUMETSAT, India, Japan, PRC, Russia and USA together with a representative of WMO.

I/1 Coordination of frequency allocations: SFCG, ITU and WRC activities

A summary of the results of the 1997 Space Frequency Coordination Group (SFCG) meeting, held in Galveston (Texas, USA), was presented in document USA-WP-14. This meeting, which took place in September 1997 was held just before WRC97. The SFCG agreed on a briefing document for the WRC, which included common positions of Space Agencies. This document had proven to be very useful in the proceedings of WRC97. The next SFCG meeting will be held in Kyoto, Japan, in September 1998.

Documents WMO-WP-12, USA-WP-15, and EUM-WP-14 reported on the outcome of WRC97, which took place between 27 October and 21 November 1997 in Geneva, Switzerland. The conference was attended by 2500 delegates from ITU member organisations, UN organisations and observers. Overall, the results of WRC97 related to meteorological applications were very good. This was possible due to intense coordination efforts between meteorological organisations and user groups including CGMS. Main results of the Conference were as follows:

401-403 MHz: This band is used for DCS operations of meteorological satellite systems. Since 1992 there were attempts to obtain a primary status for the Meteorological Satellite Service. WRC97 has agreed to this upgrade. It has to be noted that there is also a primary allocation for Meteorological Aids covering the same band but that also includes the sub-band 403 – 406 MHz. It will be necessary to coordinate between these two meteorological services to avoid interference.

Proposals for primary allocations for the Mobile Satellite Service in ITU Regions 1 and 3 within the frequency band **1675 to 1683 MHz** were not accepted by WRC97 due to unavailability of a suitable partner band in the Space to Earth direction. This request from the MSS community would have resulted in a co-use of the sub-band, which would have implied limitations to Meteorological Satellite operations.

New frequency allocations were obtained in the frequency bands **7750 – 7850 MHz** and **25.5 – 27.0 GHz**. These allocations are very important for the operations of future meteorological polar orbiting satellite systems. The allocation in the X-band around 8 GHz will be used for data transmissions of global data sets to main reception stations. It was possible to maintain the existing allocation in the band 7450 – 7550 MHz with a restriction to operations from geostationary satellites. Both allocations guarantee simultaneous operations from both types of systems. The new allocation in the band

25.5 – 27 GHz will be required for down-links from future Earth Exploration Satellite systems including meteorological systems. This new wide band allocation will become very important in the near future when satellites with new sensors are operated which require wide band downlinks which could not be accommodated in the present L-band allocations around 1.7 GHz.

One of the major achievements of WRC97 was the re-allocation of frequency bands in the range **50 – 71 GHz**. This re-allocation was necessary to allow simultaneous operations of passive sensor operations, inter-satellite communications, and fixed communication services. The new frequency plan in the band 50 – 71 GHz gives all involved services a basis for reliable operations. The operations of active communication services in such bands would have destroyed the capabilities for these important oxygen absorption measurements.

Unfortunately, it was not possible to achieve a global primary allocation in the frequency band 18.6 – 18.9 GHz, which is required for passive sensor measurements. This topic will be raised again at WRC99.

Following this presentation of the results of WRC97 an indication of topics to be discussed at WRC99 was provided by the Chairman. The main issues for WRC99 would be related to passive sensor frequency protection. The Chairman drew the attention of the Working Group to the preparatory work already underway within WMO. This work is performed by the Rapporteur for passive sensor frequencies, Dr. Guy Rochard from Météo-France who will prepare a list of protection requirements related to these services. CGMS Members were asked to actively participate in the work of WMO by providing inputs related to their planned use of passive sensors.

ACTION 26.26 CGMS Members to provide inputs to WMO related to their planned use of passive sensors frequencies by 30 September 1998.

Another important topic on the WRC99 will be related to the frequency band 401 – 406 MHz. Parts of this band used for Meteorological Satellite Service and Meteorological Aids are requested for allocation to Mobile Satellite Services. Due to the fact that sharing between such services is not possible, an allocation to MSS in this band would reduce the band needed for Radiosonde operations and would require sharing of this service with DCP operations. WMO informed the Group that the introduction of radiosondes with reduced requirement for frequency allocations can only be expected in a timeframe of at least 12 years.

A request for co-primary allocation of Mobile Satellite Service with Met Sat in the band 1698 – 1710 MHz is prepared for WRC99. This allocation will allow timesharing operations in this band between MSS and transmissions from polar orbiting meteorological satellites (HRPT, CHRPT, AHRPT). Initial studies prepared by the MSS community had indicated good feasibility for such operations. A more detailed study produced by EUMETSAT has shown that timeshare operations resulted in significant conflicts. It was recommended that MSS allocations should not be made. The study results have already been introduced to the ITU working parties.

In addition, a new international cellular telephone system (UMTS) is planned and frequency spectrum around 2 GHz will be required for such a system. One of the identified bands for UMTS is the so-called Space Operations band around 2 GHz. The current proposal is to allocate half of the bandwidth of this service to UMTS.

ACTION 26.27 **CGMS Members to indicate their use of the 2 GHz space operations band to their national frequency authorities to avoid potential future loss of parts of this important frequency band by 30 September 1998.**

CGMS Members were invited to indicate their use of the band to their national frequency authorities to avoid potential loss of parts of this important frequency band.

ACTION 26.28 **WMO to communicate to its Members its recommendations concerning the protection of frequencies allotted to meteorological satellite operations prior to WRC99.**

I/2 Coordination of Frequency Allocation

I/2.1 Polar orbiting satellite down-link frequencies

The Working Group took note of the frequency allocation for Meteor-3M as presented in RUSSIA-WP-09. In addition possible use of frequency around 7.5 GHz for the down-link of global data in the future is under consideration.

The Chairman reminded the Group that in future there would be several polar satellite systems (e.g. NOAA, Meteor, FY1, ADEOS, Metop) simultaneously using similar frequencies in the bands 137-138 MHz and 1698-1710 MHz, therefore careful coordination of frequencies used for direct broadcast would be necessary in order to avoid a real risk of interference. Precise details of orbit type (sun synchronous or not) equator crossing time, whether morning or afternoon etc, were essential.

USA, endorsing the request of the Chairman for all CGMS Members to coordinate their use of frequencies, suggested that CGMS adopt a plan which will be acceptable to all satellite operators. The following actions were agreed:

ACTION 26.29 **(i) All satellite operators to send to the CGMS Secretariat, by 31 January 1999, their planned use of frequencies in the bands 137-138 MHz and 1698-1710 MHz, together with full details of satellite orbits and other relevant supporting information.**

(ii) The CGMS Secretariat to consolidate all of these inputs and provide the information to NOAA in order to perform computer simulations.

ACTION 26.30 **NOAA to perform computer simulations leading to the preparation of a draft plan identifying potential areas of interference, for discussion at CGMS XXVII.**

ACTION 26.31 **CGMS Members to do their utmost to determine sources of interference to geostationary meteorological satellite services and report to CGMS XXVII.**

I/2.2 Interference of DCP Frequencies

The satellite operators provided information on interference to DCP channels (regional and international). USA had suffered severe interference to at least one channel in the past but this had largely disappeared in recent months. USA regularly conducted "cleaning exercises" to ensure that DCP assignments are efficiently utilised.

Russia reported severe interference across all of its DCP channels, rendering nominal operations impossible. Russia had developed a higher power, high speed DCP, for its Regional DCS, to try to overcome the problem. The Chairman reminded the Group that such a DCP, if used with other satellite systems, would adversely affect the performance of their satellite DCP transponders.

PRC also noted strong interference to FY2 DCP channels. Japan had recorded, in JAPAN-WP-07, strong interference to several GMS IDCS channels and lighter interference in other IDCS channels. In some cases, the level of this interference had increased significantly in the last year.

India commented that whilst some of its DCP user agencies had reported some interference of the INSAT Regional DCP channels, the overall operation of the INSAT DCS by India Meteorological Department had not been adversely affected.

EUMETSAT reported that a "radar signal" type of interference affecting the whole of the Meteosat down-link band had been present since the start of operations in 1977, however, the performance of the transponder AGC was sufficient to recover from the spike so that data was not normally lost. Recently EUMETSAT had noted a significantly higher (10dB) level of interference in data transponded by Meteosat-5 at 63° East. Preliminary tests of the Meteosat-5 DCS have, however, shown negligible interference to IDCS channels.

The Chairman commented that whilst it was very difficult to identify the location of an interference source, he welcomed any attempt by CGMS Members to identify such sources. The Working Group was reminded that DCP frequencies (401-403 MHz) were now primary status and identified sources of interference could be used for formal complaint to the ITU.

Concluding the discussion of this topic, the Working Group took note of the MTSAT frequency utilisation plan and was pleased to note that it conformed with CGMS recommendations.

I/3 Issues arising from CGMS XXVI plenary discussions

I/3.1 Expansion of the IDCS

The Chairman recalled the proposal to extend the IDCS from 33 to 40 channels as described in EUM-WP-7 and the response from Japan in JAPAN-WP-06. The allocation of the IDCS channels lay between the upper and lower Regional channel allocations, and there was only limited scope for any future expansion of the IDCS. The Group had to decide on the IDCS requirements in the long term (e.g. next 10-15 years).

ACTION 26.32 **CGMS Members to analyse requirements for future use of the IDCS in the next 10-15 years and to consider the possible reconfiguration of the IDCS to narrower bandwidth channels and report to CGMS XXVII.**

USA recalled that there would be a need to accommodate some experimental high rate DCPs, which may have to make use of a specific block of channels. Periodic policing of DCP operations helped to ensure efficient use of available channel capacity. Additionally, there was now a need to assess the trend in utilisation of the IDCS over the years and predict future use of the system. Consideration of the use of narrower bandwidth channels (e.g. 1.5 KHz) should also be considered, in addition to the use of higher rate DCP. Overall, the USA noted that there did not appear to be a need for an expansion of the IDCS in the short term.

EUMETSAT confirmed that some IDCS channels currently used for “regional applications” would be released following the launch of MSG at the end of 2000.
It recalled the need to maintain some spare capacity in the IDCS to accommodate DCP affected by channel interference.

Concluding discussion of this topic, the Group confirmed that there did not appear to be an urgent need to expand the IDCS in the short term, however, requirements for additional channels in the future have to be established.

I/3.2 Higher speed DCP

The Group recalled the progress being made by CGMS Members in the development of higher speed DCP (300 and 1200bps), as described in JAPAN-WP-08, RUS-WP-07 and USA-WP-13. EUMETSAT reported that the modulation scheme used by the USA prototype DCP could not be supported by the MSG transponder. It should be investigated whether modification could be possible to allow operation with all CGMS coordinated satellites.

Japan commented that it had successfully operated a high speed DCP for around ten years, although the data from this system was not processed by the nominal IDCS reception system.

The Chairman encouraged CGMS Members to study the impact of high speed DCP on normal IDCS operations.

ACTION 26.33 **CGMS Members to report on the development and operation of higher-rate DCP at CGMS XXVII and to study the impact of such systems upon nominal IDCS operations.**

USA informed the meeting that it expected to develop 10 prototype higher rate DCP during 1998 for regional use and would report back to CGMS XXVII on their operation. The Chairman recommended that the CGMS XXV ACTION addressing this issue be revitalised so that all satellite operators could report to the next meeting of CGMS accordingly.

REPORT FROM WORKING GROUP II: SATELLITE PRODUCTS

II/0 Introduction

The Working Group on Satellite Products (WG II) was attended by twelve members representing all six satellite operators. WG II was chaired by Dr Paul Menzel of NOAA.

II/1 Image Processing Techniques

JAPAN-WP-14 reported on a digital signal processing technique that presents the oversampled 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.

II/2 Satellite Data Calibration

Seven papers were presented on techniques for radiometric calibration, indicating the continued emphasis for quantitative application of the satellite data. At CGMS XXV, it was agreed that designated CGMS Members would collect data sets with overlap between the NOAA-14 polar orbiting sensors (HIRS or AVHRR) and the geostationary imagers (GMS, Meteosat, and GOES) and these data sets would be used to infer a relative calibration between the different sensors. Initial efforts were focused on inter-comparison of infrared window radiances.

EUM-WP-16 detailed a method for intercalibration and reported on the results for Meteosat-6, GOES-8, and NOAA-14 AVHRR. An agreement within 1-2% for the calibration coefficients was found, which translates to uncertainties of about 1-2° K for typical sea surface temperatures. Meteosat–6 was found to be about 1.3° K colder than NOAA-14 AVHRR and 0.8° K warmer than GOES-8.

JAPAN-WP-12 presented progress in the intercalibration performance of the infrared window on GMS-5 and NOAA-14 AVHRR. Staying near nadir in clear skies, MSC found GMS-5 to be colder by about 1.3° C than NOAA-14 AVHRR with a scatter of about 0.2° C.

USA-WP-20 described the NESDIS approach which emphasises near nadir viewing while allowing some cloud in the scene and averages radiances to 100 km resolution. Initial results suggest that all the geostationary infrared window sensors are within 0.8 C of the AVHRR (GOES-8/9 are 0.2° C colder, GMS-5 is 0.5° C colder, and Meteosat-6 is 0.8° C colder). The Working Group noted that these results from the three satellite centres compare very well (within 1° K) and felt that significant progress has been made toward establishing good intercomparison skills at all centres.

PRC-WP-08 informed the Working Group on the preliminary research on the intercalibration of FY-2A, GMS-5, and NOAA-14. Efforts have been made to account for differences in spectral response functions and to minimise differences in observation times, view angles, and pixel locations. The broad infrared window on FY-2 (10.5 to 12.5 microns) suggested intercalibration with the AVHRR split window bands individually and combined. Initial results with limited data sets were encouraging and the intent to do more research was indicated. Working Group II encouraged PRC to evaluate the advantages of the combined split window comparison and to infer GMS-5 intercalibration with NOAA-14 from their work with FY-2A.

Russia gave an oral presentation on their efforts to calibrate GOMS-Elektro infrared observations using collocated Meteosat-6 radiances. Fast radiance transfer calculations and effective cloud identification schemes have been the focus of early work; to date results have not been stable with differences greater than 2° K. Preliminary indications are that intercalibration procedures should be more robust using Meteosat-5 data from its new location (63° E). In addition, the possibility of acquiring AVHRR data near GOMS-Elektro nadir will be explored with CGMS Member help.

EUM-WP-17 provided an update on the communications with the CEOS Working Group on Calibration and Validation (Cal/Val) which is also coordinating and pursuing activities in the area of satellite calibration and inter-calibration. WG II noted the good level of information exchange between the two groups. It was also suggested that CGMS inform ISSCP of their intercalibration efforts.

ACTION 26.34 USA forward CGMS calibration papers to ISSCP and seek their comments.

USA-WP-22 presented a basic strategy for post-launch calibration and characterisation of visible and near infrared satellite sensors. Calibration from radiometrically stable desert sites, model simulations, and aircraft campaigns were discussed. The challenge for good visible calibration is daunting and requires more attention from the satellite operators.

In order to assist CGMS Members with their calibration efforts, PRC offered other satellite operators to make use of data from their Gobi desert site for visible calibration and their Qing Hai Lake site for infrared calibration. The members of WG II gratefully acknowledged the importance of this data and PRC's efforts to provide them. EUMETSAT noted the importance of this data especially during the INDOEX experiment while Meteosat-5 is positioned at 63° E.

Further discussion revealed that some imagery used in winds processing is not calibrated; this should be avoided for intercalibration exercises. It was suggested that the operational calibration habits of all the satellite operators need to be summarised and presented at CGMS XXVII. This will help assure that intercalibration has the best opportunity for succeeding.

ACTION 26.35 CGMS Members to present their operational calibration practices at CGMS XXVII.

The need for intercalibration efforts in the microwave region was noted. ESA volunteered to present a paper at CGMS XXVII on the progress reported at a recent workshop on the subject of Cal/Val with active microwave sensors. In addition, the

CEOS Working Group on Cal/Val will be approached for their reports on calibration of passive microwave sensors.

ACTION 26.36 **EUMETSAT to invite ESA to present a paper at CGMS XXVII on calibration of active microwave sensors.**

The Working Group concluded their discussion on satellite calibration by suggesting that activities in the next year should include more intercomparisons, in order to establish more statistically significant results, adjustment of the respective intercalibration algorithms to incorporate new ideas presented at CGMS XXVI, and attempts to achieve absolute calibration using ground instrument sites (such as Qing Hai Lake). The members noted that an overall strategy for intercalibration appears to be within reach.

ACTION 26.37 **CGMS Members to report on algorithm adjustment, continued inter-comparisons (expanding to other spectral bands such as the split window and water vapour bands), and absolute calibration attempts at CGMS XXVII.**

II/3 Vertical Sounding

EUM-WP-19 gave a status report on the software development concerning the ATOVS and AVHRR Processing Package (AAPP). A preliminary version of the software on CD ROM is available to the ITOVS community for extended beta testing; information is available on the EUMETSAT Web server at http://www.eumetsat.de/area4/aapp. The Working Group noted its gratitude to EUMETSAT for coordinating this international effort and for expediting the sharing of ingest, navigation, calibration, mapping, cloud mask, and pre-processing code.

USA-WP-17 reported on the continued progress toward operational use of the GOES sounders. The GOES-8 and -9 sounders continue to produce operational soundings every hour over North America and nearby oceans. Derived product images of atmospheric instability are proving useful to forecast offices in assisting the delineation of severe weather watch boxes. Moisture retrievals are also being used operationally in the Eta model with good results. GOES data is positive impact in NWP is expected to increase as direct assimilation of GOES sounder radiances becomes a reality in late 1998. 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 and the NESDIS Forecast Products Development Team Web page at http://orbit7i.nesdis.noaa.gov:8080/goes.html.

USA-WP-18 presented the report from the ITWG to CGMS. The Working Group felt that communication with the ITOVS community was facilitated by these reports and noted that many of the actions requested by ITOVS in their February 1997 meeting were receiving attention. It suggested that the next ITOVS study conference (to be held in February 1999) consider the following items for discussions:

(a) The use of satellite radiances or retrievals over land needs further attention, as there is a growing need for improved use of satellite data in some land areas of the globe;

surface emissivity effects must be accommodated to achieve positive results. ITWG guidance on appropriate methods is requested.

(b) The a.m. and p.m. polar satellites are likely to have different sounding capabilities. ITWG is requested to study how to mitigate the effect of these differences in weather applications (including NWP).

(c) The importance of good characterisation of total system spectral response functions has been stressed in past reports. ITWG is asked to investigate how good current estimates are and how good they need to be in various parts of the infrared spectrum.

(d) Geostationary sounding is evolving toward greater capability with higher spectral resolution. ITWG is asked to consider the trade-offs between spectral and spatial resolution and the information content of geostationary soundings in an era of polar orbiting satellites with high spectral resolution sounders on three platforms.

ACTION 26.38 **The CGMS rapporteur on ITWG to present a report at CGMS XXVII on ITSC X in particular addressing the issues raised at CGMS XXVI.**

ACTION 26.39 **EUMETSAT to present a report on using satellite data over land at CGMS XXVII.**

II/4 Other Parameter Extraction

EUM-WP-21 presented their thoughts regarding the transfer of research developments into operations. The process includes concept maturation, algorithm development, software coding, testing in research environment, integration into operational environment, testing by non-developers, testing in operational environment, and confirmation that user requirements are fulfilled.

JAPAN-WP-15 explained that a committee of mainly satellite data users within the JMA Headquarters guides the transition from research to operations by encouraging development activities within the MSC. In the USA transfer from research (characterised by high risk and low cost) to operations (characterised by high cost and low risk) is accomplished by experimental investigations and demonstration tests. Experimental research data sets from aircraft, research satellites, or special operational satellite schedules are processed to confirm feasibility of a new product. A several month real time demonstration under operational conditions shows new product usefulness and software robustness; after agreement from the Product Oversight Panels, approval and resources are sought from the Satellite Products and Services Review Board.

EUM-WP-20 presented results from the ECMWF study on the impact of satellite data in 4DVAR analysis. TOVS radiances (including water vapour radiances over land), geostationary winds, ERS scatterometer surface measurements, and SSMI total water vapour all showed positive impact in tropical, north, and south latitudes. JMA indicated that operational assimilation of ERS-2 scatterometer data in their operational global model had just started (early July 1998) following positive results in the observation system experiments. It was noted that the success of four-dimensional variational assimilation approaches implied that the time of a satellite observation has become vital information that must be contained in the data record. WG II suggested the following action:

ACTION 26.40 **CGMS Members to initiate an action such that satellite data and products records would be adjusted to contain the exact time and location of the observations and report at CGMS XXVII.**

INDIA-WP-02 presented an overview of operational INSAT and TOVS products. In addition to winds, OLR, QPE, and SST are inferred from geostationary data. TOVS products include temperature and moisture profiles as well as total ozone. Vegetation indices are processed from AVHRR data.

JAPAN-WP-13 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 lat and 0.25 lon resolution. It was suggested that temporal consistency cloud checks might be a useful addition.

USA-WP-16 presented a short survey of the evolution of the use of satellite data in an integrated way with data from other observing systems. It outlined the success of satellite data providing information on high clouds to complement the automated surface observing system detection of low and middle clouds. It emphasised the challenge of utilising a spectrum of observing systems to accomplish improved quantitative precipitation estimates (QPE). The Working Group noted that collaboration between various observing system groups should be fostered and that the challenge of QPE was very pressing and important.

A full agenda was concluded with discussions on the importance of establishing improved quality indicators of satellite products and better guidance on their usage for forecasters. Establishing the flags is one matter and education and training on their use is another. These subjects will explored further at CGMS XXVII.

REPORT FROM WORKING GROUP III: SATELLITE TRACKED WINDS

III/1 Preparation of the 4th International Workshop on Winds

The Working Group on Satellite Tracked Winds (WG III) was chaired by Dr. Nobuo Sato of JMA and Dr. Johannes Schmetz of EUMETSAT assisted as Rapporteur.

WG III started with a discussion regarding the preparations for the 4th International Winds Workshop (IWW4) to be held in Saanenmöser, Switzerland in October 1998. The Working Group was informed that there would be six sessions (current systems, assimilation in NWP, other applications, microwave and lidar, verification and objective quality analysis, new developments) and three working groups (methods, utilisation, verification and quality indicators). The members of WG III encouraged the IWW4 to make a record of their accomplishments in the context of CGMS priorities and to review the scope of their future meetings. It recommended to IWW4 to emphasise discussions on automatic quality flagging of satellite wind vectors and also to review the current evaluation methods of satellite winds in general. In addition it was noted that utilisation of the information contained in satellite tracked wind fields by NWP remains a major challenge; IWW4 was encouraged to continue its discussions of this important issue.

ACTION 26.41 **Members of the organising committee of IWW4 to report on the outcome of the workshop at CGMS XXVII.**

A discussion on the scope of the future IWWs concluded with a recommendation to keep the focus on geostationary satellite-tracked winds. A special session could be added on other wind retrievals, as it is already planned for IWW4.

ESA reported on a joint ESA/EUMETSAT workshop on 'Emerging Scatterometer Applications' to be held in Noordwijk, The Netherlands, at the beginning of October 1998.

III/2 Wind Statistics

Several papers reported on the wind statistics. EUM-WP-23 described the performance of EUMETSAT cloud motion winds over the period from April 1997 to April 1998 in comparison with radiosonde data. No significant change in quality has been observed during this period. It was suggested that the monthly wind performance statistics could be added to the EUMETSAT WWW home page.

JAPAN-WP-16 recorded the current status of the accuracy of GMS cloud and water vapour motion winds. The results are in-line with the performance statistics of other satellite operators. The paper noted a semi-annual cycle in the performance statistics, which is explained by the changing wind regimes over the radiosonde stations used in the comparison.

JAPAN-WP-17 presented the current development status of the satellite wind product for MTSAT as well as first validation results. For the operational schedule it is planned to have two successive 15-minute scans of the NH followed by a full disk scan at specific times of the day. This will provide an image triplet for the winds derivation with 15 minute intervals. A comparative study of 30 minute- versus 15 minute-scanning intervals shows a 20 % increase in the yield of satellite vectors when using the short interval images for the wind derivation.

The Working Group welcomed the study by JMA and suggested that IWW4 takes up this item for discussion. It was also suggested that other satellite operators should investigate the possibility of 15 minute-scans for satellite winds.

ACTION 26.46 **The CGMS rapporteur at the Winds Workshop to raise at IWW4 the issue of utility and trade-offs of shorter time interval scans for the derivation of global wind fields and report to CGMS XXVII.**

ACTION 26.47 **All satellite operators to investigate the current possibilities for scans at shorter time intervals (15 minutes) for the derivation of spatially denser and more accurate wind fields and report to CGMS XXVII.**

EUM-WP-24 presented the development plans of EUMETSAT for the wind product from the Meteorological Product Extraction Facility (MPEF). The areas where the current MPEF product will be improved are:

(1) Low-level coverage around developing tropical systems. This is important for hurricane forecasting.
(2) Low-level height assignment in trade wind inversion areas. In the inversion areas, the temperature-to-pressure transformation is multi-valued. This results in low-level IR height assignment problems.
(3) Medium-level coverage. Although this area presents fundamental meteorological problems, the MPEF wind coverage at medium levels seems to be even poorer than from the old MIEC system.
(4) High-level height assignment for cloud tracked winds. Significant scope for improvements to the semi-transparency correction.
(5) Increased resolution in time (<= 3h) for 4-D assimilation. This can only be achieved by generation of fully automated wind products.
(6) Provision of reliability indicators for speed, direction, pressure and temperature.
(7) Decrease the required amount of detailed manual quality control.

After some discussion WG III favoured the proposal to encode satellite winds in BUFR, since it provides a framework for more information on accuracy and wind vector positioning, as well as exact timing of the product retrieval. The information is especially useful in future 4-d variational assimilation schemes. The Working Group III also posed a corresponding action on IWW4.

ACTION 26.48 **The CGMS rapporteur at the Winds Workshop to raise at IWW4 the issue of encoding all satellite tracked winds with**

relevant auxiliary information in BUFR and report to CGMS XXVII.

ACTION 26.49 **All satellite operators to consider an encoding of their wind products in BUFR including the delivery of auxiliary information on the quality, etc. of winds and report to CGMS XXVII.**

The Working Group concluded with the observation that the new high-resolution wind products are not yet readily assimilated by NWP centres. This will entail further research and progress on the user side in the area of satellite data assimilation.

REPORT FROM WORKING GROUP IV: GLOBAL CONTINGENCY PLANNING

The Working Group, under the Chairmanship of Dr.T. Mohr, EUMETSAT, comprised representatives of the satellite operators EUMETSAT, India, Japan, PRC, Russia and USA together with representatives of WMO.

The Chairman recalled the joint contingency actions between EUMETSAT and USA and the long-term agreement between these two satellite operators. He added that, more recently, discussions had been initiated with 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 to provide a temporary WEFAX image dissemination service.

The Working Group expressed great interest in the plenary presentations addressing regional contingency planning from Japan and China (JAPAN-WP-04 and PRC-WP-05) and were pleased to note that preliminary discussions were already in progress on this subject between the two satellite operators.

Japan informed the Working Group that there was currently no funding foreseen to provide a back-up capability for the MTSAT satellites. Japan added that there was already approximately a 70% overlap in the fields of view of GMS/MTSAT and FY-2 which, in effect, provided a limited imaging back-up capability.

Responding to a comment from USA that there might be some scope for a small relocation of either MTSAT or FY-2 (e.g. 5-10°), in order to improve the level of overlap, Japan indicated that because MTSAT was a multi-functional satellite, providing telecommunications and aviation services in addition to the meteorological mission, there was no possibility to relocate the satellite.

Noting that each satellite operator had to respond to both national and international requirements, the Chairman commented that it may be appropriate for each operator, in the event of a major system failure, to provide back-up in areas such as product generation.

Confirming its desire to meet both national and international requirements and indicating its intention to continue the FY-2 meteorological satellite programme, PRC informed the Working Group that it will continue to study the possibilities for regional back-up operations. WMO noted the existing requirements for the space-based Global Observing System and contingency planning.

In view of the above comments, the Working Group suggested that Japan and PRC study possibilities for back-up of product generation and inform the next CGMS of progress in their discussions.

WMO noted the existing requirement for continuous observation from 76° East from GOMS in geostationary orbit and agreed to reconfirm this requirement through correspondence with Roshydromet and the Russian Space Agency.

India informed the Group that its INSAT series of satellites were also multi-functional, providing telecommunication, broadcast and meteorology missions. The Working Group was pleased to note that INSAT image data was now freely available to all external users. The exchange of image data was normally agreed via bilateral agreements. The Working Group welcomed this and encouraged India to actively promote its use throughout the Indian Ocean region. In response, India agreed to forward such encouragement to higher authorities.

The Working Group also recalled the established CGMS principles with regard to contingency planning. In response to these principles, India also agreed to transmit to higher authorities the need for regional contingency planning in the Indian Ocean region.

NOAA/NESDIS reminded the Group that although the risk of a failure of a launcher or satellite is always present, it was often hard to accommodate such failure when preparing budgets for satellite systems. Recalling that a replacement satellite launch would normally take well in excess of 6 months and frequently much longer, the need for a regional back-up capability from neighbouring satellite operators was paramount. NOAA/NESDIS added that the eventual procurement of back-up facilities became easier once effective back-up measures (e.g. GOES DCP support to EUMETSAT and EUMETSAT support to the GOES programme through the use of Meteosat-3) had been demonstrated.

In closing the session, the Chairman recorded the following actions generated by the Working Group:

ACTION 26.50 **Japan and PRC to study the possibilities for back-up of product generation and inform CGMS XXVII of the progress in their discussions.**

ACTION 26.51 **WMO to reconfirm the requirement for a Russian Federation geostationary satellite at 76° East over the Indian Ocean through correspondence with Roshydromet and the Russian Space Agency by 31 August 1998.**

ACTION 26.52 **India to study possibilities for supporting the CGMS principles on regional contingency planning and transmit them to higher authorities and report at CGMS XXVII.**

ACTION 26.53 **India to actively promote the use of INSAT data throughout the Indian Ocean region and inform CGMS XXVII of such use.**

FINAL PLENARY SESSION

SENIOR OFFICIALS MEETING

J.1 APPOINTMENT OF CHAIRMAN

The CGMS XXVI Senior Officials meeting was convened at 9.00 a.m. on 10 July 1998 and elected Dr. Itoh and Dr. Hinsman as Co-Chairmen.

J.2 REPORTS FROM THE WORKING GROUPS

The reports from the four Working Groups were presented by their Chairmen: Mr. R. Wolf (WG I on Telecommunications), Dr. P. Menzel (WG II on Satellite Products), and Dr. Sato (WG III on Satellite-tracked Winds), Mr. Gordon Bridge, on behalf of Dr. Mohr (WG IV on Global Contingency Planning).

The Senior Officials took note of the reports and thanked the Participants, Chairmen and Rapporteurs for their active and fruitful discussions. They endorsed the proposed actions and recommendations formulated.

The Senior Officials congratulated the four Working Groups for their comprehensive reports and for their achievements since the last meeting of CGMS.

J.3 NOMINATION OF REPRESENTATIVES AT WMO AND OTHER MEETINGS

The Senior Officials agreed that:

- Dr. Menzel will represent CGMS at the next meeting of the ITWG (in Boulder in February 1999),
- CGMS Secretariat will represent CGMS at the WMO Congress in May 1999,
- CGMS Secretariat will represent CGMS at the CBS Meeting in October 1998,
- TBD from CGMS Secretariat, as appropriate, will represent CGMS at the WMO CBS/WG-Sat or its successor,
- Dr. J. Schmetz will be Rapporteur at the Winds Workshop,
- Mr. R. Wolf will represent CGMS at the SFCG and WRC,
- CGMS Secretariat will represent CGMS at CEOS Plenary in November 1998 in Bangalore.

J.4 ANY OTHER BUSINESS

CGMS noted that no issue was raised under this agenda item.

J.5 SUMMARY LIST OF ACTIONS

(i) Permanent actions

1. All CGMS Members to inform the Secretariat of any change in the status or plans of their satellites to allow the updating of the CGMS Tables of Satellites.

2. The Secretariat to review the tables of current and planned polar and geostationary satellites, and to distribute this updated information, via the WWW Operational Newsletter, via Electronic Bulletin Board, or other means as appropriate.

3. All satellite operators to circulate regular satellite operational reports.

4. All satellite operators to provide NOAA/NESDIS with information on unexplained anomalies for study, and NOAA to provide solar event information to the satellite operators on request and a status report on the correlation study at each meeting.

5. All CGMS Members to regularly verify the consolidated list of IDCP assignments through the online service provided by the CGMS Secretariat.

6. All satellite operators to regularly provide WMO with information on the number of meteorological satellite reception stations in their areas of responsibility.

7. All CGMS Members to inform users to register user stations within their area of responsibility.

8. CGMS Members generating Satellite Tracked Winds to check that the following monthly statistics are sent and received on a quarterly basis via the CGMS server supported by WMO: number of co-locations, temporal and spatial co-location thresholds; and radiosonde inclusion/exclusion criteria.

9. CGMS Members also participating in the CEOS Cal/Val should ensure the complementarity of activities and report at CGMS and CEOS Cal/Val meetings as required.

Outstanding actions from previous meetings

ACTION 25.05 EUMETSAT to provide CGMS Members with direct FTP access, via Internet, to the IDCS database.

ACTION 25.07 USA, with the assistance of the CGMS Secretariat, to develop a primary set of reporting statistics on IDCS performance to be provided as feedback to DCP Operators and the WMO on a quarterly basis by 31 August 1998.

ACTION 25.08 CGMS Secretariat, with the assistance of WMO, to implement an IDCS end-to-end system test at the time of the regular WMO monitoring of the GTS in the period 1-15 October 1998, and report results to CGMS XXVII.

ACTION 25.09	WMO to distribute the results of IDCS end-to-end system tests to the appropriate bodies with WMO (e.g. CMM and CBS).

(iii) Actions from CGMS XXVI

ACTION 26.01	CGMS Members to review and provide comments to NOAA regarding NOAA's 300 bps and 1200 bps DCP design and certification procedures, by 31 August 1998.
ACTION 26.02	NOAA to present at CGMS XXVII, a proposed design and certification plan for 300 bps DCPs for acceptance as a "standard" by CGMS Members at CGMS XXVII.
ACTION 26.03	All CGMS Members to inform the CGMS Secretariat by 15 September 1998 on any action planned to minimise the impact of the Leonid meteor storm expected in autumn 1998 for posting on the CGMS home page.
ACTION 26.04	WMO and CGMS satellite operators to express to the USA by their assessment of the difficulties anticipated for the global community resulting from the change of HRPT modulation scheme for NOAA-N and -N' and offer support to the USA in receiving a waiver by 30 July 1998.
ACTION 26.05	CGMS satellite operators to inform WMO of the actions they propose to take in support of the WMO Strategy of Improved Satellite System Utilisation by April 1999.
ACTION 26.06	WMO to continue the rolling review process to include additional applications of relevance to CGMS satellite operators and data impact studies and to present another iteration of the Statement of Guidance at CGMS-XXVII.
ACTION 26.07	WMO to inform GCOS that CGMS suggested that GOSSP develop its own Statement of Guidance for requirements within their purview for consideration at a future CGMS.
ACTION 26.08	CGMS Members to forward to EUMETSAT their final comments on the IDCS Users Guide by 31 August 1998.
ACTION 26.09	Russian Federation, People's Republic of China to share their information and experience relevant to the interference on DCP channels in the GOMS and FY-2A areas of coverage.
ACTION 26.10	USA to forward its final comments on LRIT Global Specification Issue 2.5, by 31 July 1998.
ACTION 26.11	Russia, India to forward by 31 August 1998 their final comments on the proposed LRPT/AHRPT specifications.

ACTION 26.12	EUMETSAT to propose an outline of a Broadcast Format Guide to be developed with input from all CGMS Members, by 30 September 1998.
ACTION 26.13	CGMS Members to indicate points of contact and provide input to the Broadcast Format Guide by 1 January 1999.
ACTION 26.14	WMO to inform the relevant CBS Working Group of the requirements of some members of CGMS requirement for a common code table to identify a particular instrument for satellite data and products.
ACTION 26.15	WMO to initiate a study on the possibilities of meeting WMO requirements for digital satellite image data exchange, taking into account the future trends in communication technology.
ACTION 26.16	EUMETSAT to invite ESA to report at CGMS XXVII on the status of the Envisat mission.
ACTION 26.17	CGMS Members to nominate a point of contact to contribute to the development of the new Consolidated Report by 31 August 1998.
ACTION 26.18	CGMS Members to forward to J. Morgan by 31 August 1998 their inputs to the second release of the CGMS Directory of Meteorological Satellite Applications.
ACTION 26.19	EUMETSAT to coordinate with UN-OOSA participation of CGMS in UNISPACE III.
ACTION 26.20	CGMS satellite operators to inform WMO of past and planned tests of year 2000 compliance for communication to WMO Members via the WWW Newsletter.
ACTION 26.21	CGMS representative to make a presentation at CBS on behalf of CGMS on the Members' plans addressing year 2000 compliance of their operational satellite systems.
ACTION 26.22	All CGMS satellite operators to express to EUMETSAT their position regarding CGMS views on CBS restructuring, by 30 September 1998.
ACTION 26.23	EUMETSAT to forward to the President of WMO, by 15 November 1998 an agreed response by CGMS Satellite Operators to the CBS restructuring proposal, with respect to satellite activities and cooperation with CGMS.
ACTION 26.24	WMO to inform the other CGMS Members on detailed procedures to be followed for placing CGMS working papers on the WMO Satellite Activities server (http://sat.wmo.ch).

ACTION 26.25	CGMS to distribute the working papers for CGMS XXVII in an electronic form via the WMO Satellite Activities server (http://sat.wmo.ch).
ACTION 26.26	CGMS Members to provide inputs to WMO related to their planned use of passive sensors frequencies by 30 September 1998.
ACTION 26.27	CGMS Members to indicate their use of the 2 GHz space operations band to their national frequency authorities to avoid potential future loss of parts of this important frequency band by 30 September 1998.
ACTION 26.28	WMO to communicate to its Members its recommendations concerning the protection of frequencies allotted to meteorological satellite operations prior to WRC99.
ACTION 26.29	(i) All satellite operators to send to the CGMS Secretariat, by 31 January 1999, their planned use of frequencies in the bands 137-138 MHz and 1698-1710 MHz, together with full details of satellite orbits and other relevant supporting information. (ii) The CGMS Secretariat to consolidate all of these inputs and provide the information to NOAA in order to perform computer simulations.
ACTION 26.30	NOAA to perform computer simulations leading to the preparation of a draft plan identifying potential areas of interference, for discussion at CGMS XXVII.
ACTION 26.31	CGMS Members to do their utmost to determine sources of interference to geostationary meteorological satellite services and report to CGMS XXVII.
ACTION 26.32	CGMS Members to analyse requirements for future use of the IDCS in the next 10-15 years and to consider the possible reconfiguration of the IDCS to narrower bandwidth channels and report to CGMS XXVII.
ACTION 26.33	CGMS Members to report on the development and operation of higher-rate DCP at CGMSXXVII and to study the impact of such systems upon nominal IDCS operations.
ACTION 26.34	USA forward CGMS calibration papers to ISSCP and seek their comments.
ACTION 26.35	CGMS Members to present their operational calibration practices at CGMS XXVII.

ACTION 26.36	EUMETSAT to invite ESA to present a paper at CGMS XXVII on calibration of active microwave sensors.
ACTION 26.37	CGMS Members to report on algorithm adjustment, continued inter-comparisons (expanding to other spectral bands such as the split window and water vapour bands), and absolute calibration attempts at CGMS XXVII.
ACTION 26.38	The CGMS rapporteur on ITWG to present a report at CGMS XXVII on ITSC X in particular addressing the issues raised at CGMS XXVI.
ACTION 26.39	EUMETSAT to present a report on using satellite data over land at CGMS XXVII.
ACTION 26.40	CGMS Members to initiate an action such that satellite data and products records would be adjusted to contain the exact time and location of the observations and report at CGMS XXVII.
ACTION 26.41	Members of the organising committee of JWW 4 to report on the outcome of the workshop at CGMS XXVII.
ACTION 26.42	JMA to report at IWW4 in a working group meeting on a comparison of monthly wind statistics based on circular and elliptic collocation areas.
ACTION 26.43	All satellite operators to consider to place their monthly performance statistics on their WWW home pages.
ACTION 26.44	EUMETSAT to implement and maintain on its home page a section on "selection/rejection criteria at NWP centres for satellite tracked winds".
ACTION 26.45	The CGMS rapporteur at the Winds Workshop to raise at IWW4 the issue whether the current information on "selection/rejection criteria at NWP centres for satellite tracked winds" is complete and sufficient for a comparison of the different implementations of the utilisation of satellite tracked winds at NWP centres and report to CGMS XXVII.
ACTION 26.46	The CGMS rapporteur at the Winds Workshop to raise at IWW4 the issue of utility and trade-offs of shorter time interval scans for the derivation of global wind fields and report to CGMS XXVII.
ACTION 26.47	All satellite operators to investigate the current possibilities for scans at shorter time intervals (15 minutes) for the derivation of spatially denser and more accurate wind fields and report to CGMS XXVII.

ACTION 26.48	The CGMS rapporteur at the Winds Workshop to raise at IWW4 the issue of encoding all satellite tracked winds with relevant auxiliary information in BUFR and report to CGMS XXVII.
ACTION 26.49	All satellite operators to consider an encoding of their wind products in BUFR including the delivery of auxiliary information on the quality, etc. of winds and report to CGMS XXVII.
ACTION 26.50	Japan and PRC to study the possibilities for back-up of product generation and inform CGMS XXVII of the progress in their discussions.
ACTION 26.51	WMO to reconfirm the requirement for a Russian Federation geostationary satellite at 76° East over the Indian Ocean through correspondence with Roshydromet and the Russian Space Agency by 31 August 1998.
ACTION 26.52	India to study possibilities for supporting the CGMS principles on regional contingency planning and transmit them to higher authorities and report at CGMS XXVII.
ACTION 26.53	India to actively promote the use of INSAT data throughout the Indian Ocean region and inform CGMS XXVII of such use.

J.6 APPROVAL OF DRAFT FINAL REPORT

The plenary session, with the Senior Officials present, reviewed the draft Final Report of the meeting and approved it with minor amendments. The Secretariat agreed to include all the amendments in a revised version, which would be distributed to CGMS Members for final comments prior to publication.

It was agreed that the final version of the report would be made available through normal and electronic mail to the participants.

J.7 DATE AND PLACE OF NEXT MEETINGS

CGMS was very pleased to accept an offer by China to host CGMS XXVII in 1999, at a date and place to be agreed upon between the host and Secretariat.

On behalf of all participants, Dr. Hinsman thanked JMA for its generous hospitality and for all the arrangements, which allowed such fruitful discussions in the beautiful surroundings of Nikko.

Mr. Itoh thanked all the participants and the Chairman for their contributions, which resulted in so much progress being made over the five days of the meeting. He wished success to all participants for their undertakings.

Mr. Wolf expressed his high appreciation of the progress made on all CGMS actions.
He thanked WMO for representing the user community and Dr. Hinsman for his skilful chairmanship.

Dr. Gupta thanked EUMETSAT for arranging his participation in CGMS XXVI. All participants joined him in thanking the Secretariat for its efficient support to the meeting and expressed gratitude to JMA for its excellent hospitality.

The meeting was adjourned at 11.30 a.m. on 10 July 1998.

Annex 1

AGENDA OF CGMS XXVI
6-10 July 1998

A. INTRODUCTION

A.1 Welcome
A.2 Election of Chairman
A.3 Adoption of Agenda and Work Plan of Working Group Sessions
A.4 Nomination of WG Chairmen, Rapporteurs and Drafting Committee
A.5 Review of Action Items

B. REPORT ON THE STATUS OF CURRENT SATELLITE SYSTEMS

B.1 Polar Orbiting Meteorological Satellite Systems
B.2 Geostationary Meteorological Satellite Systems
B.3 Anomalies from solar and other events

C. REPORT ON FUTURE SATELLITE SYSTEMS

C.1 Future Polar Orbiting Meteorological Satellite Systems
C.2 Future Geostationary Meteorological Satellite Systems

D. OPERATIONAL CONTINUITY AND RELIABILITY

D.1 Global planning, including orbital positions
D.2 Inter-regional contingency measures
D.3 Long-term global contingency planning

E. SATELLITE REQUIREMENTS OF WMO PROGRAMMES

E.1 World Weather Watch
E.2 Other Programs

F. COORDINATION OF INTERNATIONAL DATA COLLECTION & DISTRIBUTION

F.1 Status and Problems of IDCS
F.2 Ships, including ASAP
F.3 ASDAR
F.4 Dissemination of DCP messages (GTS or other means)

G. COORDINATION OF DATA DISSEMINATION

G.1 Dissemination of satellite images via satellite
G.2 Dissemination of satellite products via satellite, GTS or other means
G.3 Global exchange of satellite image data via satellite or via the GTS

H. OTHER ITEMS OF INTEREST

H.1 Applications of Meteorological Satellite Data for Environment Monitoring
H.2 Search and Rescue (S&R)
H.3 Meteorological Data Distribution via satellite
H.4 Training
H.5 Information
H.6 Any other business

---------- PARALLEL WORKING GROUP SESSIONS ------------

WORKING GROUP I: TELECOMMUNICATIONS

I/1 Coordination of frequency allocations: SFCG, ITU and WRC activities
I/2 Telecommunication techniques
I/3 Issues arising from CGMS XXVI plenary discussion
I/4 Conclusion and preparation of the WG report

WORKING GROUP II: SATELLITE PRODUCTS

II/1 Image processing techniques
II/2 Satellite Data Calibration
II/3 Vertical sounding and ITWG matters
II/4 Other parameters and products
II/5 Coordination of Code forms for satellite Data
II/6 Coordination of Data Formats for the Archive and Retrieval of Satellite Data
II/7 Conclusion and preparation of the WG Report

WORKING GROUP III: SATELLITE TRACKED WINDS

III/1 Preparation of the 4th International Workshop on Winds
III/2 Wind Statistics
III/3 Procedures for the exchange of inter-comparison data
III/4 Derivation of Wind Vectors
III/5 Conclusion and preparation of WG report

WORKING GROUP IV: GLOBAL CONTINGENCY PLANNING

------------ FINAL SESSION (SENIOR OFFICIALS MEETING) ---------

J.1 Appointment of Chairman of final session
J.2 Reports from the Working Groups
J.3 Nomination of CGMS Representatives at WMO and other meetings
J.4 Any Other Business
J.5 Summary List of Actions from CGMS XXVI
J.6 Approval of Draft Final Report
J.7 Date and Place of Next Meetings

WORKING PAPERS SUBMITTED TO CGMS-XXVI

EUMETSAT

EUM-WP-01	Review of Action Items	A.5
EUM-WP-02	Status of the Meteosat System and Indoex Support	B.2
EUM-WP-03	Status of Preparation of EPS (Space and Ground Segment)	C.1
EUM-WP-04	Status of Preparation of MSG	C.2
EUM-WP-05	Network of EUMETSAT Satellite Application Facilities	C.2
EUM-WP-06	CGMS Home Page Consolidated Report	H.5
EUM-WP-07	Expansion of the International Data Collection System (IDCS)	F.1
EUM-WP-08	Status and Problems of the IDCS	F.1
EUM-WP-09	Specification for Future Direct Broadcast Services from Polar Orbiting Satellites	G.1
EUM-WP-10	Proposal for a Broadcast Format Guide	G.1
EUM-WP-11	Report on EUMETSAT Training Activities	H.4
EUM-WP-12	EUMETSAT Conferences and Publications	H.5
EUM-WP-13	The CGMS Directory of Meteorological Satellite Applications	H.5
EUM-WP-14	Report on the Outcome of the World Radio Conference 1997	I.1
EUM-WP-15	EUMETSAT External Information System – Status Update	I.3
EUM-WP-16	Satellite Inter-Calibration of IR Window Observations	II.2
EUM-WP-17	CEOS CAL/VAL Satellite Cross Calibration Project	II.2
EUM-WP-18	Proposed CGMS Contribution to UNISPACE III	H.5
EUM-WP-19	The EUMETSAT AAPP Development – Status as of May 1998	II.3
EUM-WP-20	Impact of Satellite Data on the ECMWF 4DD-VAR Analyses	II.4
EUM-WP-21	EUMETSAT Experience in Transferring into Operation the Results of Research on Product Development	II.4
EUM-WP-22	Development of the Unified Archive and Retrieval Facility (UMARF)	II.6
EUM-WP-23	EUMETSAT Satellite Tracked Wind Radiosonde Collocation Statistics	III.2
EUM-WP-24	Wind Products Development Plan of the EUMETSAT MPEF	III.4
EUM-WP-25	Use of Satellite Tracked Winds by NWP Centres	III.4
EUM-WP-26	Preparation of the Year 2000	H.6
EUM-WP-28	Status of LRIT/HRIT Global Specification, MSG Mission Specific Implementations and Related Matters	G.1
EUM-WP-29	Application and Presentation Layer Specifications for LRIT/LRPT/HRIT/HRPT Data Formats	G.1

INDIA

IND-WP-01	Status of Indian National Satellite (INSAT) System Having Meteorological Payload	B2
IND-WP-02	Derivation of Operational Satellite Products in IMD	II.4

JAPAN

JAPAN-WP-01	Review of Action Items from Previous CGMS Meetings	A.5
JAPAN-WP-02	Status of Geostationary Meteorological Satellites	B.2
JAPAN-WP-03	Future Geostationary Meteorological Satellite Systems	C.2
JAPAN-WP-04	Possibility to develop Regional Contingency Arrangement	D.2
JAPAN-WP-05	Status of IDCS	F.1
JAPAN-WP-06	Expansion of the IDCS in the Year 2000 time frame	F.1
JAPAN-WP-07	Monitoring of Interference in IDCS Channels	F.1
JAPAN-WP-08	Dissemination of IDCP Messages	F.4
JAPAN-WP-09	Dissemination of Data by LRIT	G.1
JAPAN-WP-10	Exchange of Satellite Image Data via the GTS including Satellite Image Data Dissemination to EUMETSAT	G.3
JAPAN-WP-11	Developing of CAL System in MSC	H.4
JAPAN-WP-12	The Intercalibration Activities	II.2
JAPAN-WP-13	Product of Satellite Cloud Grid Information Data	II.4
JAPAN-WP-14	Study on over-sampling for Imager	II.1
JAPAN-WP-15	Procedures for Transferring into Operation the Results of Research on Product Development	II.4
JAPAN-WP-16	Current Status of GMS Cloud Motion and Water Vapor Motion Wind	III.2
JAPAN-WP-17	Products of Satellite Winds for MTSAT	III.4
JAPAN-WP-18	DCP Relay System Operating at Higher Data Rate	F.1

PEOPLES REPUBLIC OF CHINA

PRC-WP-01	The Status of FY-2A: Check out and Operation	B.2
PRC-WP-02	The Operation Statistics of FY-2A Satellite	B.2
PRC-WP-03	The Status of FY-1C Programme	C.1
PRC-WP-04	The Plan of FY-2B	C.2
PRC-WP-05	The Concept of the Contingency Plan for Geostationary Meteorological Satellites between China and Japan	D.2
PRC-WP-06	The Report on the Interference of FY-2A DCS	F.1
PRC-WP-07	The Transmission Characteristics of FY-2A S-VISSR Data	G.1
PRC-WP-08	The Preliminary Research on the In-Flight Relative Calibration of FY-2 Satellite Scan Radiometer	II.2

RUSSIAN FEDERATION

RUS-WP-01	Status of Meteor Polar Orbiting Meteorological Systems	B.1
RUS-WP-02	Status of GOMS/Elektro Geostationary Operational Meteorological System	B.2
RUS-WP-03	Future Polar Orbiting Meteorological Systems	C.1
RUS-WP-04	Future Geostationary Meteorological Satellite GOMS N 2	C.2
RUS-WP-05	Status of WEFAX Dissemination via GOMS/Elektro Satellite	G.1
RUS-WP-06	Status of DCP Messages Dissemination via GOMS/Elektro Satellite	F.4

RUS-WP-07	The Development of DCP Relay System operating at 1200 bps	F.4
RUS-WP-08	Dissemination of Satellite Products via INTERNET	G.2
RUS-WP-09	Roshydromet Activities on Coordination and Frequency Allocation	I.1

USA

USA-WP-01	Review CGMS XXIV Actions Items	A.5
USA-WP-02	Report on the Status of Current Operating Systems	B.1
USA-WP-03	Satellite Solar Anomalies	B.3
USA-WP-04	Future Polar Orbiting Meteorological System	C.1
USA-WP-05	Modifications to NOAA-N and N'POES' S-Band Transmitters and the Impacts on users of High Resolution Picture Transmission Data	C.1
USA-WP-06	Report on the Status of Future Geostationary Meteorological Satellite Systems	C.2
USA-WP-07	IDCS Modifications	F.1
USA-WP-08	Coordination of the International Data Collection and Distribution (ASAP)	F.2
USA-WP-09	Coordination of the International Data Collection and Distribution (GTS)	F.4
USA-WP-10	Report in Development of the Low Rate Picture Transmission Specification (LRPT)	G.1
USA-WP-11	Ocean Remote Sensing: a Comprehensive Program to Observe Oceanographic Phenomena from Space	H.1
USA-WP-12	Information on U.S. DCS Regulations	H.6
USA-WP-13	300bps DCP Certifications	H.6
USA-WP-14	Summary of the 1997 Space Frequency Coordination Group Meeting	I.1
USA-WP-15	Results of the WRC 97	I.1
USA-WP-16	The Evolution of the Use of Satellite Data in Integrated Ways	II.4
USA-WP-17	GOES Temperature and Moisture Soundings in 1997	II.3
USA-WP-18	Report on ITSC-IX to CGMS XXVI	II.3
USA-WP-19	1997 Report on NOAA/NESDIS Automated Cloud-Motion And Water Vapor Drift Vectors	III.4
USA-WP-20	Intercalibration of GOES, Meteosat, HIRS and AVHRR Infrared Radiances	II.2
USA-WP-21	Program for Intercalibration of GMS, GOES and Meteosat Versus HIRS and AVHRR Infrared Radiances	II.2
USA-WP-22	Basic Strategy for the Post-launch Calibration and Characterisation of Visible and Near-Infrared Meteorological Satellite Sensors	II.2

WMO

WMO-WP-01	Databases	H.5
WMO-WP-02	Review of Action Items from previous CGMS Meetings	A.5
WMO-WP-03	Matters related to APT/WEFAX and Conversion	G.1
WMO-WP-04	CGMS List Servers and Home Pages	H.5
WMO-WP-05	WMO Strategy to Improve Satellite System Utilisation	E.1
WMO-WP-06	Education and Training Strategy	H.4
WMO-WP-07	Statement of Guidance on Feasibility of Meeting WMO Requirements	E.1
WMO-WP-08	Review of Satellite Related WMO Publications	H.5
WMO-WP-09	Digital Satellite Image Data Exchange over the GTS	G.3
WMO-WP-10	ASDAR Status Report	F.3
WMO-WP-11	WMO Code Form Changes	G.2
WMO-WP-12	Radio Frequency Matters	I.1
WMO-WP-13	Report on GCOS Activities	E.2
WMO-WP-14	Tropical Cyclone Programme Requirements	E.1
WMO-WP-15	ASAP Status Report	F.2
WMO-WP-16	CBS Restructuring	H.6
WMO-WP-17	Year 2000 Problem	H.6

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APPENDIX A:

SELECTED PAPERS SUBMITTED TO CGMS XXVI

CGMS-XXVI
PRC WP-01
Agenda Item: B2

The Status of FY-2A: Check Out and Operation

Summary

FY-2A was launched on 10 June 1997. This paper describes the procedure of check out, the result of check out and the defects of FY-2A in check out and operation

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CGMS-XXVI
PRC WP-01
Agenda Item: B2

The Status of FY-2A: Check out and Operation

China launched the first geostationary meteorological satellite FY-2A on 10 June 1997. At 15:50 17 June, S-band telemetry link was switched on and 1702.5MHz telemetry signal was received by CDAS. From 17 June to 25 August FY-2A was in check out phase and from 1 October it was quasi-operational. From 1 January ,1998 FY-2A began operation until 8 April ,1998 . After 8 April FY-2A stopped operation.

1. The Procedure of Check Out

On 18 June ,1997 the S-band telecommand system was switched on

On 21 June ,1997 the first VIS image was acquired and the S-VISSR image was generated.

On 23 June ,1997 the Turn Around Ranging System was switched on and measured the distances between satellite and 3 ranging stations. As well as the control test from CDAS to ranging stations and voice communication between CDAS and ranging stations have been done. The data collection platform system was connected and the standard platform transmitted 401.2 MHz signal carrier signal and report data to FY-2A.

On 5 July ,1997 the cover of radiation cooler of radiator was thrown away. CDAS sent commands to turn on and turn off repeatedly the heating and de-contaminating of the primary and secondary radiation cooler.

On 10 July, 1997 the heating and de-contaminating of the primary and secondary radiation cooler has been completed, and the radiation cooler began cooling spontaneously.

On 12 July, 1997 the temperature of the secondary cooler reduced to 97 K and reached the requirement on acquiring image.

On 13 July, 1997 the first IR and WV image have been acquired and the data of Space Environment Monitor has been separated to monitor the environment of FY-2A. Then all the functions on image acquiring, data broadcasting, data collecting and space environment monitoring have been realized.

On 1 August, 1997 the Australia Ranging Station (TARS-2) was connected.

From 2 to 5 August the 72 hours automatic operation has been implemented.

On 25 August ,1997 the system check out has been completed.

2. The Result of Check Out

The test result of FY-2A communication link is shown in table 1.

Table 1. The Test Result of Satellite Transponders

Item	Equipment		Measuring	Designing
EIRP (dbm)	Transponder I		57.01	56.5 ± 1
	Transponder II	Telemetry	47.03	4.3
		S-FAX	49.7	46
	Transponder III		21.3 (per channel)	19.78
G/T (db/K)	Transponder I		-14.3	-15.1
	Transponder II		-14.3	-15.1
	Transponder III		-17.02	-18.0
	Transponder I		~~2.68~~ $\times 10^{-7}$	10^{-6}
	Transponder II		3.15×10^{-7}	10^{-6}
	Transponder III		4.3×10^{-7}	10^{-6}
Input / Output	Consistent with the test on ground			

The power level of CDAS up-link is shown in Table 2.

Table 2. The power level of CDAS up-link

Signal	The power level of CDAS up-link
S-VISSR	90 w ± 1 db
WEFAX	90 w ± 1 db
S-FAX	100 w ± 1 db
Ranging CDAS	45 w ± 1 db
TARS-1	40 w ± 1 db
TARS-2	80 w ± 1 db
DCP	5 w ± 1 db
Command	5 w ± 1 db

The results of check out showed that the data format, frequency, modulation, signal level, and electronic-magnetic compatibility matched finely each other between satellite and ground system.

Generally speaking the quality of images of VIS, IR and WV is good.

3. The defects of FY-2A in check out and operation

A. In the period of satellite eclipse there were "white swath" in IR and WV images due to the direct illuminating on detectors. The position of the "white swath " on the images was moved day by day in the period of satellite eclipse. The width of "white swath " was about 80 lines. Therefore the image information on these areas were lost in 90 days eclipse period each year.

B. Analyzing the histogram of VIS image, it was shown that the dynamic range was not enough. The gray scale was only 0-40 and did not reach 0-63.

C. After satellite being launched for 10 months, the s-band antenna could not point at the Earth due to the defect of de- spin subsystem. Unfortunately since 8 April FY-2A operation has been interrupted and stopped to broadcast image. Now the related Chinese facilities are actively working to solve this technical problem . The further progress will be circulated .

CGMS-XXVI
WMO WP-7
Prepared by WMO
Agenda item: E.1

STATEMENT OF GUIDANCE AND THE FEASIBILITY OF MEETING WMO REQUIREMENTS

(Submitted by the WMO)

Summary and purpose of document

This document informs CGMS of a Preliminary Statement of Guidance and of the Feasibility of Meeting WMO Requirements.

ACTION PROPOSED:

CGMS Members to respond to the Preliminary Statement of Guidance and of the Feasibility of Meeting WMO Requirements

Appendix: Preliminary Statement of Guidance Regarding How Well Satellite Capabilities meet WMO Users Requirements in Several Application Areas

DISCUSSION

1. The third session of the CBS Working Group on Satellites (WGSAT) was informed that the Commission for Basic Systems at its eleventh session (CBS-XI 1996) had endorsed the procedure called the Rolling Review of User Requirements developed at its second session. The procedure reviews the users' requirements for observations and the capabilities of existing, planned and proposed observing systems, and develops guidance on appropriate observing systems to meet the users' requirements in cooperation with the Working Group on Observations. Four steps are implied in this review: (1) develop user requirements, (2) summarize observing system capabilities, (3) perform a critical review comparing (1) and (2), and (4) develop a statement of guidance and of feasibility of meeting the requirements. CBS-XI requested the WGSAT to continue with the procedure and to document, as appropriate, each step in the review process in order to maintain a heritage as well as an ability to provide feedback to the technical commissions.

2. In the second session, progress was made in developing a capability for a critical review of observational data requirements. An analysis was performed to clarify and interpret the requirements for all WMO Programmes and used as input for various sources of data requirements. At the time, an overall approach adopted was the use of Order of Magnitude (OOM) to express representative requirements for selected applications. The use of OOM allowed the selected application requirements to be expressed as: a single value with a half order of magnitude range, an adequate range that was a half order of magnitude range centred on the requirement, a target range that was a quarter OOM range higher, and a useful range that was a quarter OOM range lower. The second session agreed upon an action item to complete a "Critical Review."

3. A draft "Critical Review" was prepared using the observational requirements and distributed to WGSAT members for comments. Feedback indicated strong concern that the preliminary results showed little contribution by satellite systems towards meeting requirements. An in-depth review indicated that the Order of Magnitude (OOM) method of setting the boundaries for the "Target," "Needed," and "Threshold" ranges was inappropriate. Furthermore, it showed that the boundaries for ranges should be based on the requirements themselves and not on an assumption on instrument improvements. The in-depth review also recalled that the original set of WMO requirements had included maxima and minima. Therefore, it was agreed that the Order of Magnitude (OOM) method should be re-evaluated with the possibility of replacing it with a Max/Min method. Thus the max/min method as described in the following paragraphs has been evaluated as the most appropriate means of stating requirements for the purpose of making comparisons with expected instrument performances.

4. In the text of a given application (use), requirements for observations can be stated quantitatively in terms of a set of relevant parameters, of which the most important were horizontal and vertical resolution (hor and vert res), frequency (observing cycle), timeliness (delay of availability) and accuracy. For each application, there was usually no abrupt transition in the utility of an observation as its quality changed; improved observations (in terms of resolution, frequency, accuracy, etc.) were usually more useful while degraded observations, although less useful, were usually not useless. Moreover, the range of utility varies from one application to another.

5. This problem was addressed by stating requirements for each parameter in terms of two values, an upper boundary or "maximum" and a lower boundary or "minimum" requirement. The "maximum" requirement (or "optimum requirement" or "goal" as expressed by the upper boundary) was the value which, if exceeded, would not yield significant improvements in performance for the application in question. Therefore, the cost of improving the observations beyond this requirement would not be matched by a corresponding benefit. Maximum requirements were likely to evolve as applications progress and they develop a capacity to make use of better observations.

6. The "minimum" requirements (or "threshold" as expressed by the lower boundary) was the value below which the observation would not yield any significant benefit for the application in question (or below which the benefit derived would not compensate for the additional cost involved in using the observation). Assessment of minimum requirements for any given observing system was complicated by assumptions concerning which other observing systems were likely to be available. It may be

unrealistic to try to state the minimum requirement in an absolute sense, because the very existence of a given application relied on the existence of a basic observing capability. Within the range between the maximum and minimum requirements, the observations become progressively more useful. In summary, an evaluation showed that the best method to state WMO observation requirements was in terms of Max/Min.

7. Since the second session, the sub-group on Satellite Data, Product and Service Requirements has met once in Paris, France, 27-30 May 1997. At that meeting, there was discussion and agreement regarding the structure of the Database on User Requirements and Space Capabilities and its content. It was agreed that a draft Statement of Guidance should be the goal of the third session of the working group.

8. The third session noted that a presentation on the Rolling Review of User Requirements was made to the Working Group on Observations (WG/OBS) in Geneva, Switzerland, during the week of 27 October 1997. The WG/OBS recognized the strong synergy between the ongoing activities of the WGSAT and the WG/OBS with regard to comparing observational requirements with the existing and expected observing system performances. The WG/OBS agreed to work with the WGSAT to extend the requirements review process to include evaluation of in-situ observing systems.

9. The third session was also informed that in March 1998 the Quensha Satellite Products Analysis in five areas (Nowcasting, Synoptic Meteorology, Global Numerical Weather Prediction, Hydrology, and Atmospheric Chemistry) were distributed to members of the WGSAT. These analyses were intended to assist in the preparation of a critical review as input for the drafting of a statement of guidance and of feasibility of meeting the user requirements.

10. With regard to the Statement of Guidance, its presentation must be concise, attractive, and understandable to senior managers and decision makers, whilst retaining sufficient detail to represent adequately the full range of observation requirements and satellite capabilities. It should have the following attributes:

- its presentation of the user requirements must be accurate; although necessarily a summary, it must be recognizable to experts in each application as a correct interpretation of their requirements,
- its presentation of the satellite system capabilities must be accurate; although also a summary, it must be recognizable to expert satellite data users as a correct interpretation of the systems' characteristics and potential,
- its results must accurately reflect the extent to which current systems are useful in practice, whilst drawing attention to those areas in which they do not meet some or all of the user requirements,
- its process must be as objective as possible,

11. The role of the Statement of Guidance is to provide an interpretation of the output of the Critical Review, to draw conclusions and to identify priorities for action. The third session agreed that the Statement of Guidance would be most valuable to space agencies as well as aid in helping them obtain funding.

12. The process of preparing the Statement of Guidance will be necessarily more subjective than that of the Critical Review. Moreover, whilst the Critical Review attempted to provide a comprehensive summary, the Statement of Guidance should be more selective, drawing out key issues. It is at this stage that judgements are required concerning, for example, the relative importance of observations of different variables.

13. The Statement of Guidance, together with the output of the Critical Review, is intended to serve two audiences:

- It informs WMO and its Members on the extent to which their requirements are met by present systems, will be met by planned systems, or would be met by proposed systems. It would also provide the means whereby Members, through the Technical Commissions, could check that their requirements have been correctly interpreted and could update them if necessary, as part of the rolling process.

- It provides support materials to WMO and its Members in dialogue with satellite agencies regarding whether existing systems should be continued or modified or discontinued, whether new systems should be planned and implemented, and whether research and development would be needed to meet unfulfilled aspects of the user requirements.

14. Based on the above discussion, the third session drafted a Statement of Guidance regarding how well satellite capabilities met WMO User Requirements in several application areas. This document is contained in the Appendix. It contains guidance in five application areas: NWP, synoptic meteorology, nowcasting, hydrology and agricultural meteorology.

15. This now completes the first cycle of the Rolling Requirements Review process and represents the achievement of a major milestone in the WGSAT's ongoing work plan. The outcome is preliminary and will be progressively matured in the second and subsequent review cycles. However, it does demonstrate that the Rolling Requirements Review process is starting to work.

PRELIMINARY STATEMENT OF GUIDANCE REGARDING HOW WELL SATELLITE CAPABILITIES MEET WMO USER REQUIREMENTS IN SEVERAL APPLICATION AREAS

EXECUTIVE SUMMARY

A review of how well satellite capabilities meet WMO user requirements has been exercised by the CBS Working Group on Satellites for some WMO applications (NWP, synoptic meteorology, nowcasting, hydrology, and agricultural meteorology). This review has utilized a maturing database of satellite capabilities and user requirements. An objective critical review has produced evaluation charts. A subjective interpretation of these charts by satellite experts has generated statements of guidance in these applications areas. Some preliminary conclusions regarding satellite capabilities are:

* There is a continuing need in all application areas for operational continuity of a suite of instruments deployed from at least two polar orbiting platforms and at least five geostationary platforms.

* NWP will benefit from the recent microwave enhancements of AMSU to the polar satellites (for a clear and cloudy sky sounding capability) and is awaiting high spectral resolution measurements from instruments such as AIRS, IASI, and CrIS (for enhanced vertical resolution in clear sky soundings), planned for the 2000s. Measurement of wind profiles remains the most challenging (remote sensing lidar systems offer promise, but need the opportunity to mature). Variational data assimilation techniques offer potential for improved exploitation of observations with high temporal frequency, such as radiances from instruments on geostationary satellites; for this reason, user requirements are evolving as assimilation techniques mature. It is becoming clear that expansion of geostationary capabilities to include high vertical resolution clear sky soundings from high spectral resolution infrared systems and all sky soundings from microwave systems will be very useful.

* Current satellite systems are unable to satisfy all the user requirements for synoptic meteorology simultaneously with those for nowcasting; at present, rapid small-scale observations impede the regular larger scale observations. The timely delivery of satellite data and information to users remains a major challenge. Accurate precipitation estimates remain elusive. Both application areas have need of higher temporal and spatial resolution of measurements such as those to be offered by MSG in the next decade.

* Hydrology is anticipating some improvement in estimates of snow cover, snow water equivalent, and soil moisture from the experimental ADEOS-II and EOS microwave instrument (AMSR). Operational implementation of microwave capabilities and expansion of VIS/IR and TIR capabilities remain challenges for basin scale modelling of water and energy balances.

* Agricultural meteorology needs leaf area index and land cover measurements with higher spatial resolution; the polar orbiting instruments need to be enhanced to resolve sub 1 km features. Multifrequency synthetic aperture radar systems should be considered as they could offer significant improvements to canopy structure and water content determinations useful in this application area.

1. INTRODUCTION

1.1 The CBS Working Group on Satellites (WG-SAT) has been attempting to establish a procedure whereby WMO can assess how well satellite capabilities meet their user requirements. To this end WG-SAT has been collecting the requirements for observations to meet the needs of all WMO Programmes and also cataloguing the current and planned provision of observations from environmental satellites. The resulting database is nearly in final form and is called the Database on User Requirements and Space Capabilities. WG-SAT has been testing a procedure called the Rolling Requirements Review (RRR) within which user requirements and satellite system capabilities are compared in an objective way using analysis tools established for the purpose. This Critical Review is conducted for each application area and precedes the drafting of a Statement of Guidance. WG-SAT has completed one cycle of the review process. The Commission for Basic Systems (CBS) has requested that WG-SAT document, as appropriate, each step in the review process in order to maintain a heritage as well as an ability to provide feedback to the technical commissions. This document records the initial Statements of Guidance (SOG).

1.2 The aim of the Statement of Guidance, together with the output of the Critical Review, is:

- to inform WMO Members on the extent to which their requirements are met by present systems, will be met by planned systems, or would be met by proposed systems. It also provides the means whereby Members, through the Technical Commissions, can check that their requirements have been correctly interpreted and can update them if necessary, as part of the Rolling Requirements Review process.

- to provide resource materials useful to WMO Members for dialogue with satellite agencies regarding whether existing systems should be continued or modified or discontinued, whether new systems should be planned and implemented, and whether research and development is needed to meet unfulfilled aspects of the user requirements.

1.3 The Rolling Requirements Review (RRR) procedure consists of four stages:

(i) a review of users' requirements for observations, within areas of applications covered by WMO programmes;

(ii) a review of the observing capabilities of existing and planned satellite systems;

(iii) a "Critical Review" of the extent to which the capabilities (ii) meet the requirements (i); and

(iv) a "Statement of Guidance" based on (iii).

Activities (i), (ii) and (iii) have been undertaken within CBS-WG-SAT, in consultation with related activities of the Global Climate Observing System's (GCOS) Global Observing System Space Panel (GOSSP) and CEOS. Only a selected number of application areas have been addressed; many applications remain to be analyzed by WG-SAT and other expert groups (for example it is anticipated that GCOS will study global and regional climate applications).

1.4 The RRR

- has generated a database compendium of WMO user requirements and satellite observing capabilities that is proving useful to a broad community;

- has addressed only the satellite component of the observing system; a more complete RRR will include both in situ and satellite observing systems;

- identifies gaps and overlaps in existing and planned satellite capabilities, and indicates the user requirements satisfied by these satellite systems;

- strives to address user requirements in a technology free way giving little consideration to measurement characteristics, observing platforms, or data processing systems; and

- does not include cost considerations.

1.5 The SOG

- relies on interpretation and analysis by satellite experts;

- is guided by the critical review of the database of user requirements and satellite capabilities; and

- sets out the role for satellites, without pre-empting judgements on the best or most cost-effective mix of observations.

1.6 Scope and Limitations

It is recognized that guidance provided by WMO to satellite agencies will be only one of many inputs affecting their decisions on future systems, which will be required to meet national or regional objectives and will be constrained by available resources. However, it is hoped that guidance at this level will be helpful in promoting an integrated global observing system which provides the maximum benefit from the collective resources of WMO Members.

It is not intended that the process of reviewing requirements and providing guidance in this way should replace the need for detailed activities on the design of satellite instruments and systems, but rather that general guidance should be provided on the users' requirements for these systems. The detailed specification of satellite instruments and systems will remain a task for relevant agencies, with appropriate technical advice from specialists in the user community.

2. ROLLING REQUIREMENTS REVIEW

2.1 Summary of the Process

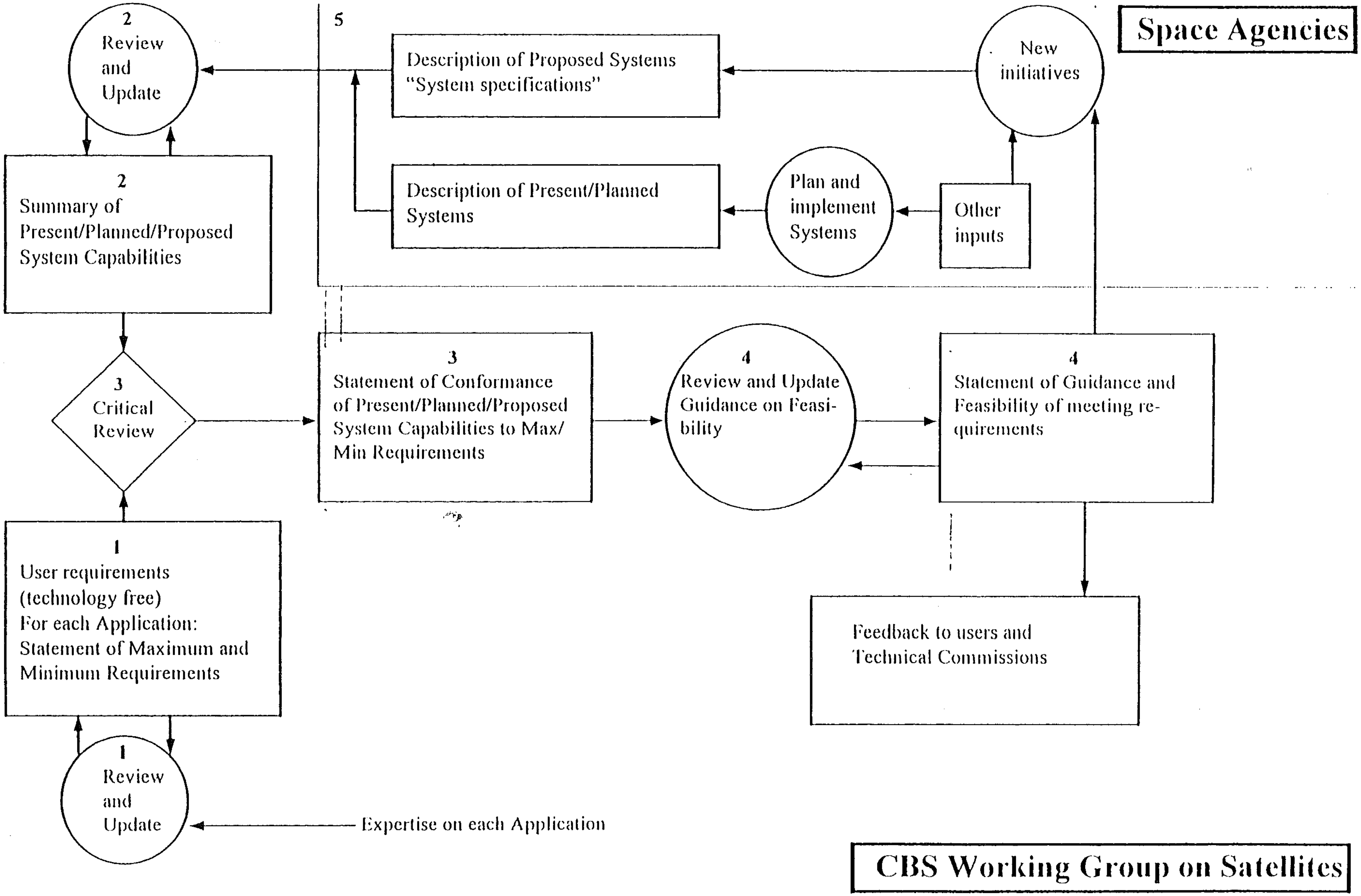
The RRR involves the four steps mentioned in 1.3. The user requirements are user oriented, not system dependent; they are intended to be technology free in that no consideration is given to what type of measurement characteristics, observing platforms, or data processing systems are necessary (or even possible) to meet them. The requirements are aimed at the 2000-2010 time frame. The comparison of requirements to capabilities utilizes the database delineating both. As the database changes better to reflect the user requirements as well as existing and planned observing capabilities, the RRR must be performed periodically. Figure 1 indicates the anticipated interactions with space agencies and user groups.

2.2 Database of user requirements and satellite system capabilities

The database structure and level of detail are designed primarily to assist the assessment of conformance between users' requirements for observations and the potential capability of the space segments of satellite systems. To this end, the information included in the database is:

- from the user communities ("Users"), a summary of their observational requirements,
- from the space agencies ("Providers"), a summary of the potential performances of their satellite instruments, expressed in the same terms as the user requirements,
- instrument and mission descriptions sufficiently detailed to support the evaluation of their performances, and
- programmatic information to permit assessment of service continuity aspects.

As the primary role of the database is to establish a bridge between Users and Providers, particular care has been taken to establish a common language, i.e. agreed definitions for the geophysical parameters for which observations are required/provided and agreed terminology to characterize requirements and performances. Users/Providers have been requested to state their


Space Agencies
5
2
Review
and
Update
Description of Proposed Systems
"System specifications"
New
initiatives
2
Summary of
Present/Planned/Proposed
System Capabilities
Description of Present/Planned
Systems
Plan and
implement
Systems
Other
inputs
3
Critical
Review
3
Statement of Conformance
of Present/Planned/Proposed
System Capabilities to Max/
Min Requirements
4
Review and Update
Guidance on Feasi-
bility
4
Statement of Guidance and
Feasibility of meeting re-
quirements
1
User requirements
(technology free)
For each Application:
Statement of Maximum and
Minimum Requirements
Feedback to users and
Technical Commissions
1
Review
and
Update
Expertise on each Application
CBS Working Group on Satellites

requirements/performances in terms of "Level II" products, wherever possible. Also, as indicated earlier, Users have been requested to supply their observation requirements in a "technology-free" manner; they should not pre-judge the type of observing system (space-borne or terrestrial) that is best suited to meet their requirements. This aspect is important for proper assessment of the potential role of space-based systems within strategies for integrated observing systems.

2.3 Satellite Capabilities

The current operational meteorological satellite observing system comprises a constellation of geostationary and polar orbiting satellites operated by various space agencies. Each satellite has a payload of instruments including as a minimum a multispectral imaging radiometer. The satellite systems capabilities database has been drafted with input from each of the operational satellite operators. This will continue to be an evolving data set and will be updated every year.

2.3.1 Polar platforms

Polar orbiters allow a global coverage to be obtained from each satellite but only twice a day. To provide a reasonable temporal sampling for many applications at least two satellites are required, thereby providing 6-hourly coverage. A backup capability exists by reactivating 'retired' platforms and this has been demonstrated recently. Since 1979, coverage with two polar orbiting satellites has been achieved most of the time. The orbital altitude of 850 km makes it technically feasible to make high spatial resolution measurements of the atmosphere/surface.

Current operational polar orbiters include the NOAA series from the US and the METEOR, RESURS, and OKEAN series from Russia and the FY-1 series from China. They provide image data that can be received locally. The NOAA satellites also enable generation of atmospheric sounding products that are disseminated to NWP centres on the GTS. In the future the NOAA AM satellite will be replaced by the METOP satellites provided by EUMETSAT.

2.3.2 Geostationary platforms

The geosynchronous orbit is over 40 times higher than a polar orbit, which makes measurements technically more difficult from geostationary platforms. The advantage of the geostationary orbit is that it allows frequent measurements over the same region necessary for nowcasting applications and synoptic meteorology. The disadvantage is that a fixed full disk view of the Earth is viewed from one satellite and so five equally spaced satellites around the equator are needed to provide complete global coverage, with the exception of the polar regions which are not viewed.

Currently, there is global coverage from geostationary orbit (>5 operational satellites) for image data and products (e.g., cloud motion winds) and 2 satellites are providing a sounding capability as well. Backup is provided by reactivating 'retired' platforms and there have been several examples of this.

Some of the satellites provide a real-time reception capability to allow immediate access to the imagery for real-time applications. Products are disseminated on the GTS by the satellite operators for near real-time applications.

2.3.3 Research and applications satellites

Research systems are valuable for demonstrating new instruments for possible future operational systems. To date, research satellites have been flown by several agencies of which TRMM, and ADEOS are examples. The soon to be launched EOS and ENVISAT platforms are another. Applications satellites with a limited number of missions, such as ERS, also provide important contributions. More recently measurements based in radio occultation technology such as the GPS/GLONASS have been added to the database of satellite capabilities. However, a long-term commitment to providing research and applications data routinely is necessary to increase the utility of these data.

2.4 User Requirements

The user requirements database has been constructed in the context of a given application (use). The requirements for observations are stated quantitatively in terms of a set of relevant parameters, of which the most important are horizontal and vertical resolution, frequency (observing cycle), timeliness (delay of availability), and accuracy. For each application, there is usually no abrupt transition in the utility of an observation as its quality changes; improved observations (in terms of resolution, frequency, accuracy, etc.) are usually more useful while degraded observations, although less useful, are usually not useless. Moreover, the range of utility varies from one application to another. The requirements for each parameter are expressed in terms of two values, an upper boundary or "maximum" and a lower boundary or "minimum" requirement. The "maximum" requirement (or "optimum requirement" as expressed by the upper boundary) is the value which, if exceeded, does not yield significant improvements in performance for the application in question. Therefore, the cost of improving the observations beyond this requirement would not be matched by a corresponding benefit. Maximum requirements are likely to evolve; as applications progress, they develop a capacity to make use of better observations. The "minimum" requirements (or "threshold" as expressed by the lower boundary) is the value below which the observation does not yield any significant benefit for the application in question (or below which the benefit derived does not compensate for the additional cost involved in using the observation). Assessment of minimum requirements for any given observing system is complicated by assumptions concerning which other observing systems are likely to be available. It may be unrealistic to try to state the minimum requirement in an absolute sense, because the very existence of a given application relies on the existence of a basic observing capability. Within the range between the minimum and maximum requirements, the observations become progressively more useful. This first iteration of the RRR showed that the preferred method to state WMO observation requirements is in terms of Max/Min.

2.5 Critical Review

The CR process compares user requirements with the satellite system capabilities and records the results, in terms of the extent to which the capabilities of present, planned and proposed systems meet the stated requirements. This is not a trivial process and considerable work has been done to evolve a process and presentation for the CR to meet the following criteria:

- its presentation must be concise and attractive, and understandable to senior managers and decision makers, whilst retaining sufficient detail to represent adequately the full range of observation requirements and satellite capabilities;

- its presentation of the user requirements must be accurate; although necessarily a summary, it must be recognizable to experts in each application as a correct interpretation of their requirements;

- its presentation of the satellite system capabilities must be accurate; although also a summary, it must be recognizable to expert satellite data users as a correct interpretation of the systems' characteristics and potential;

- its results must accurately reflect the extent to which current systems are useful in practice, whilst drawing attention to those areas in which they do not meet some or all of the user requirements; and

- its process must be as objective as possible.

Example output of the CR for wind profiles for the NWP application is shown in Figure 2. This is a single parameter for a single applications area. The CR produces hundreds of these charts, but software tools have been developed which provide the required subsets of charts to experts involved in the RRR.

The CR is, however, essentially a comparison and is not intended to be interpretative. Whilst hopefully accurate and informative, this does not provide final guidance on what to do next.

2.6 Statement of Guidance

The role of the SOG is to provide an interpretation of the output of the CR, to draw conclusions, and to identify priorities for action.

The process of preparing the SOG is necessarily more subjective than that of the CR. Moreover, whilst the CR attempts to provide a comprehensive summary, the SOG is more selective, drawing out key issues. It is at this stage that judgements are required concerning, for example, the relative importance of observations of different variables.

3. STATEMENTS OF GUIDANCE FOR FIVE WMO PROGRAMME APPLICATIONS

The following statements are intended to provide guidance concerning the requirements for satellite data applications in meteorology. The statement interprets the analysis performed during the CR, draws conclusions addressing the adequacy of the satellite observations, and suggests future progress towards an optimum use of satellite data for meteorology. Only the most significant variables in a given application area have been analyzed in the SOGs.

To facilitate reading the SOGs for the five application areas, the following terminology has been adopted. "Marginal" indicates minimum user requirements are being met in the CR, "acceptable" indicates greater than minimum but less than maximum requirements (in the useful range) are being met, and "optimum" means close to maximum requirements are being met.

3.1 Global Numerical Weather Prediction

Global Numerical Weather Prediction (NWP) models are used to produce short and medium range weather forecasts (out to 10 days) of the atmospheric state. This enables forecasters using the guidance from the NWP model outputs to issue forecasts of important weather parameters for their area of interest. Global models provide medium range forecasts everywhere averaged over a model grid size of typically 75km.

In order to initialise these models, an accurate estimate of the atmospheric state at a certain time is required from which the NWP forecasts are run. Observations from conventional surface, airborne, and spaceborne platforms are all used to define this initial state. The data requirements for global NWP are based on the need to consistently provide an accurate analysis of the atmospheric state for any given time. Validation of the model fields is also an important activity for which satellite data can be used.

Most NWP centres require that the data be available within 3 hours of measurement time, although some medium-range forecast centres can still get some benefit from the data even if it is up to 12 hours old. The key model variables for which satellite data can potentially provide an improved analysis are listed below with an assessment of whether the requirement is being met by existing or planned satellite instruments.

Wind profile 1000-500 hPa

Analysis for Global NWP

1. REQUIREMENT SUMMARY and assessment key

Satellite(s):	3	Hor	Vert	Cycle	Delay	Acc
Colour key		km	km	h	h	m/s
Optimum		50.0	0.4	1.0	1.0	1.0
Median		107.7	0.9	2.3	1.6	1.7
		232.1	2.2	5.2	2.5	2.9
Threshold		500.0	5.0	12.0	4.0	5.0

Cycle times below are mission cycle times divided by # of polar satellites needed
"Cycle" is the mission cycle time divided by the number of satellites needed.

2. Instruments for:-Wind profile 1000-500 hPa

Showing relevant instruments for which details are available

Instrument	**Hor**		**Vert**		**Cycle**	**(sats)**	**Delay**		**Acc**		**Mission**		**Orbit**
	Km		**Km**		**h**	**3**	**h**		**m/s**		**name**	**Rating**	
SEVIRI	100.0		5.0		1.0		1.0		2.0		MSG-1,,3		G3
IMAGER	150.0		5.0		3.0		1.0		3.0		GOES-9,L		G1
IMAGER	150.0		5.0		3.0		1.0		3.0		GOES-8,,M		G2
IMAGER/MTSAT	150.0		5.0		3.0		1.0		3.0		MTSAT-1		G5
MVIRI	150.0		5.0		3.0		2.0		3.0		Meteosat-3,,6		G3
MVIRI	150.0		5.0		3.0		2.0		3.0		MTP		G3
VHRR	150.0		5.0		6.0		2.0		4.0		INSAT-2A,,2E		G4
VISSR (GMS5)	150.0		5.0		6.0		2.0		3.0		GMS-5		G5

Figure 2

Wind profile

Wind profiles are currently unavailable from present systems; at best, single layer vectors are possible in clouds or moisture gradients. Atmospheric motion winds inferred from geostationary satellite images currently provide the sole source of information on wind profile measurements from satellites. The spatial coverage is optimum with the exception of the polar regions. The vertical coverage is typically marginal since at any one point only one wind vector is usually available at the uppermost cloud layer and the height assignment remains problematic. The measurement accuracy is acceptable and the horizontal resolution is acceptable below the tropopause although at mid-levels (-500 hPa) there is a reduction in the quality and quantity of winds. Above the tropopause the lack of clouds and low concentrations of water vapour result in no coverage. New technology (e.g., Doppler wind lidar) to observe the vertical wind profile is being developed.

Wind vector over sea surface

Surface wind measurements are provided by both passive and active microwave instruments. Passive imagers provide an acceptable coverage but provide information only on wind speed. The current scatterometers provide direction information also but only with marginal coverage due to 12-hour repeat cycles and narrow swaths. The accuracy is acceptable for NWP. Planned instruments will have better coverage. There is no redundancy in the present system and there may be a complete loss of data before the launch of METOP.

Temperature and Humidity profile

The accuracy of temperature and humidity profiles for NWP is acceptable over the ocean in cloud free areas, but measurements in cloudy areas remain a problem. The new microwave measurements from AMSU are expected to help in cloudy areas. More frequent geostationary soundings are also helping to expand coverage by making measurements hourly thus creating more opportunities for finding clear sky. Overall, the horizontal coverage is optimal for NWP but the vertical coverage is marginal. The latter will be improved in cloud free areas with the launch of high resolution infrared sounders planned for METOP, NPOESS, and EOS-PM. Radio-occultation measurements will also help to improve the vertical coverage. Soundings over the land have marginal accuracies. Not all the polar orbiter data are available within 3 hours of measurement time, thus reducing the potential global coverage.

Ozone total column

The accuracy of total column ozone is acceptable and will be improved with the launch of high resolution infrared sounders and more accurate solar backscatter instruments. The horizontal coverage is marginal as the total column measurements are only available in clear areas. Currently, ozone measurements are not available in real-time (except TOVS) but plans are underway to make these data available on the GTS.

Surface variables

Sea surface temperature measurements have coverage, accuracy and spatial resolution that is optimal for NWP. The diurnal cycle of sea surface temperatures is a new requirement that can only be measured marginally in most regions. For sea-ice coverage the horizontal resolution and coverage are optimal and the measurement accuracy is acceptable. The data delivery is acceptable. Snow cover, inferred from space, marginally meets NWP requirements. Future experimental satellites will measure snow cover to the desired accuracy but with no continuity. No present or planned operational missions measure soil moisture well enough to meet minimum requirements.

3.1.1 Summary of NWP SOG

Global NWP will benefit from:

- enhanced microwave instruments (such as AMSU) for cloudy sky soundings;

- high spectral resolution sounders (such as IASI, AIRS, and the planned NPOESS sounders) for improved vertical coverage; and

- 4-dimensional assimilation systems using more frequent measurements from geostationary satellites.

The critical atmospheric parameters that are not adequately addressed or measured by the current or planned satellites are:

- wind profiles at all levels;
- snow cover and equivalent water depth;
- soil moisture; and
- wind vectors over the sea surface (frequency of coverage and continuity/redundancy of missions is a concern).

3.2 Synoptic Meteorology

Synoptic Meteorology comprises all activities in a forecasting centre where meteorologists analyze all available information and communicate with users. Satellite information is most useful in areas where conventional observations are sparse or in areas of frequent severe weather events (e.g. tropical cyclones).

Synoptic applications of satellite data have a high degree of commonality with applications in nowcasting. In both cases satellite products are important to help the forecaster analyze weather developments; the time and space scales are more demanding for nowcasting. Therefore, the SOGs for synoptic meteorology and for nowcasting have many similarities. Furthermore, there is also overlap with the NWP SOG as key variables for synoptic meteorology are the output of numerical forecast models (which usually have assimilated satellite data), and ground based conventional and remote sensing observations.

Applications in synoptic meteorology are time critical. This is true not only for the delivery time but also for the time available for interpreting and digesting the available information. In addition, synoptic meteorology and nowcasting are often in conflict for the use of satellites; rapid small-scale observations can impede the regular larger scale observations.

Direct comparison of measured satellite images with simulated imagery based on radiative transfer calculations and output of regional numerical models is often very useful. The animated sequences of calculated and observed images over a few hours to one day can reveal the credibility of the synoptic development forecast by the model.

Further processing of satellite data may provide a better service to the forecasters. Automatic methods of satellite image interpretation can be used to highlight the areas of interesting weather development. Efforts are underway to process satellite data in support of high-resolution models and conceptual models for specific weather phenomena.

In summary, high quality and timely satellite image data are essential in state-of-the-art synoptic meteorology. However, direct use of satellite image data still can be improved through automatic image interpretation, helping forecasters to better synthesize the wealth of information. Satellite data are one component and not the sole source of information for the analysis and forecast of weather (the relative importance of satellite data increases with the decrease of other information). The utility of satellite data is enhanced when analyzed along with NWP forecast fields.

Cloud Cover

Existing satellite radiance data provide acceptable information on cloud cover over a large area of the globe and marginal information on height and type. Associated with cloud cover, the water vapour patterns are also acceptably depicted by the current satellites. Some systems are demonstrating a marginal capability for detecting night-time extension of fog (those with short and long wave infrared windows). Satellite measured radiances provide essential input regarding the evolution of meteorological and non-meteorological phenomena that cannot effectively be provided by any other observing system.

Wind Profiles

The requirements for synoptic meteorology, other than imagery, are marginally met by present satellite systems. Most notable is the lack of suitable satellite based systems that provide accurate wind profiles, although the currently available satellite tracked winds provide very valuable information, especially in data sparse regions. Wind vectors at the ocean surface, as derived from scatterometer data, are also important for detecting small scale features and help with providing advice to marine users.

Temperature and Moisture Profiles

Data on atmospheric temperature and humidity are currently not available in cloudy areas. They are marginal in terms of vertical resolution and accuracy in clear areas, but provide useful information. The problems are more pronounced over land than over the ocean, which is also reflected in the fact that currently satellite derived profiles over land are not being used in NWP at low levels.

3.2.1 Summary of Synoptic Meteorology SOG

The key points regarding user requirements and satellite capabilities for synoptic meteorology and its further development can be summarized as follows:

- synoptic meteorology and nowcasting are often in conflict for the use of satellites; rapid small scale observations impede the regular, larger scale observations, when performed by current instruments;

- the timely delivery of satellite data and information to users remains a major challenge;

- reliable precipitation estimates remain elusive; and

- there is a need for higher temporal and spatial resolution of measurements.

3.3 Nowcasting

Nowcasting comprises all activities in a local forecasting centre where meteorologists analyze available meteorological information and communicate weather guidance to a user community. Nowcasting covers the period of 0 to 24 hours and addresses the spatial scales sometimes less than 1 km and temporal scales on the order of one minute.

Meteorological satellite data have created many and still offer further benefits for nowcasting; they are well suited to monitoring rapid meteorological changes in space and time. Many of the requirements for nowcasting are similar to those for synoptic scale meteorology, although the timeliness and spatial resolution requirements are more stringent for nowcasting.

With nowcasting there is a high premium on the timeliness (within minutes or better), frequency (as small as 30 seconds), and horizontal resolution (1 km or better) of the satellite derived parameters. Frequency requirements dictate geostationary observing away from the polar regions.

The most significant improvements in satellite remote sensing for nowcasting will come from improved frequency and resolution of observations. Routine synoptic scale or hemispheric coverage interfere with rapid mesoscale imaging of fast moving, short duration, and intense developments.

A key component of nowcasting is the monitoring and prediction of severe weather. Here timing of significant weather announcements and forecasting likely regions for weather alert can be greatly assisted by high spatial, spectral, and temporal resolution observations. However rapid access to the data still remains a problem, and must be addressed.

Selected key variables that the satellite could provide to improve nowcasting follow:

Cloud Cover

Geostationary satellites provide useful observing frequency for cloud detection and identification of cloud type, but provide marginal spatial resolution. Infrared multispectral cloud imagery are necessary for useful night-time cloud characterization and are not provided by all satellites.

Precipitation Rate

Satellite detection of liquid precipitation does not meet threshold accuracy requirements. Precipitation rates are observed only indirectly, for example inferred from cloud temperature cooling and cloud top growth. There are significant problems with these approaches, but they could be improved, for instance, from space based lightning detection or microwave multispectral rainfall detection techniques. To date there are no concrete plans for operational implementation of these improvements.

Severe Weather Indicators

Atmospheric instability is often a harbinger of severe weather. It can be inferred from temperature and moisture profiles. The current geostationary satellite imagers do not meet threshold accuracy requirements, however geostationary sounders provide atmospheric instability information useful for nowcasting. Rapid imagery during fast developing and short duration events is critically important and is not yet provided by all satellites. In summary, current and planned systems provide marginal capability for depicting atmospheric destabilization.

Fog

Fog forecasting and monitoring is a key nowcasting activity particularly in relation to air and ground transportation forecasts. Fog extent and formation or dissipation rate can be determined by using sequential multispectral satellite imagery. Geostationary satellites currently provide images at useful temporal and spatial resolution for this purpose but do not in all cases provide useful night-time multispectral observations.

Volcanic Ash

Geostationary capabilities for nowcasting volcanic ash do not meet minimal requirements. Large expanses of the globe do not have routine multispectral imagery required for ash detection.

3.3.1 Summary of Nowcasting SOG

The following sentences provide a summary of the nowcasting SOG:

- well-defined high spatial and temporal resolution multispectral imagery from space will provide important immediate benefit to nowcasting in areas such as cloud, fog and severe weather monitoring;

- reliable precipitation estimates still remain elusive, however they will benefit from continuing enhancements to the measurement capabilities; and

- rapid imaging (on the order of minutes or less) is critical for nowcasting, but it is not yet provided by all geostationary satellites.

3.4 Hydrology

The application of satellite data to operational hydrology can be classified in two ways according to the temporal requirements: (i) the first is non- or slowly-time dependent such as topography and land use; and (ii) time dependent products needed to initialize and update forecast models such as rainfall rates or soil moisture. Satellite data, in conjunction with in situ and other data, are also used for calibration and validation of hydrological models but these data are not time dependent.

To meet hydrological forecasting needs, the data must be available within 1/2 to 6 hours, depending upon the size of the basin. This time factor could be estimated by the basic lag-time, a measure of the time response between rainfall input (or snow melt) and the runoff hydrograph. Satellite products useful to hydrology are listed below with a description of how well they meet the hydrological model needs and whether or not they are time-sensitive. For example, hydrologic variables such as snow cover, snow water equivalent and soil moisture are dynamic variables that must be updated fairly frequently. Variables where data delivery is time sensitive (less than 6 hours) are indicated.

Snow Cover

Current and planned polar orbiting satellites should provide acceptable data on snow cover. AVHRR provides marginal snow cover information; enhancement is expected with the addition of the 1.6 micron channel in 1998. The passive microwave instruments (i.e. AMSR) will be limited to dry snow up to about 80 cm deep. The visible and near infrared (i.e. MODIS) instruments will be limited by cloud cover in some regions, but the 8-day composite data should be very useful. These snow cover measurements will be acceptable for mesoscale modelling and snowmelt runoff forecasting. (Time sensitive)

Snow water equivalent

The passive microwave AMSR and SSMI will provide marginal estimates of snow water equivalents where there are validated regional algorithms. There is no general algorithm that can be applied in any region. The regional modifications are necessary to account for snow grain size (climate related), vegetation and elevation. The measurements will be acceptable for water balance studies and snowmelt runoff forecasting in large basins. (Time sensitive)

Soil Moisture

Most of the active and passive microwave instruments will provide some soil moisture information for regions of limited vegetation cover. Information regarding moisture depth will remain elusive. Unfortunately, none of the instruments provide a satisfactory combination of spatial resolution and repeat cycle time (2 to 3 days). The AMSR data may come close to providing soil moisture or land wetness information that may be marginally useful for mesoscale models. (Time sensitive)

Land surface temperature:

There are a number of satellites that will provide acceptable land surface temperatures. A few hydrologic energy and water balance models make direct use of these satellite land surface temperatures. These data should be most valuable for extrapolating between met station data, large areas, and data sparse areas. (Time sensitive)

Vegetation type and NDVI

All of the listed instruments should provide acceptable and in some cases, optimal NDVI and vegetation type data. However, in some cases, the NDVI and vegetation type products may not be interchangeable because of slightly different spectral bands. The cycle times in most cases are acceptable for NDVI and adequate for vegetation type because they do not change very rapidly. (Not time sensitive)

Short-wave outgoing radiation at TOA

Most of the instruments will provide acceptable short-wave outgoing radiation at TOA at acceptable resolution, cycle time and accuracy for most hydrologic applications. These data will be useful for basin scale modelling of water and energy balances. Some of the satellites are optimum for cycle time and accuracy. (Time sensitive)

Long-wave outgoing radiation at TOA

Most of the instruments will provide acceptable long-wave outgoing radiation at TOA at acceptable resolution, cycle time and accuracy for most hydrologic applications. These data will be useful for basin scale modelling of water and energy balances. Some of the satellites are optimum for cycle time and accuracy.

3.4.1 Summary of Hydrology SOG

The following key points summarize the SOG for hydrology applications:

- addition of future microwave satellites (ADEOS-II and EOS-PM) along with the AMSU instrument should provide enhanced observational capabilities for snow extent, snow water equivalent and soil moisture, however operational continuity of these systems is not assured;

- a number of additional satellite-derived variables are or will be extremely useful to hydrology, including but not limited to: water surface elevation, precipitation rates and totals, frozen ground, latent and sensible heat, surface air temperature and humidity, and surface winds.

3.5 Agricultural Meteorology

Agricultural meteorology is one of the fields of hydrometeorology for which satellite data are very important. Agrometeorological parameters are very variable in time and space. Information about large areas can only be obtained by remote sensing. Many agrometeorological parameters are used in different "weather yield" models for assessment of the state of the crops and forecast of their yields.

Leaf area index (LAI)

LAI is one of the principle variables sought from agrometeorological satellite data for use in "weather yield" models. It is used for the assessment of the state of the crops. The spatial coverage is acceptable for the NOAA satellites (with an observing cycle from 5 to 7 days). The time of delay of up to 1 day is acceptable, which is met by almost all instruments. The horizontal resolution of 1 km is acceptable. The measurement accuracy is a drawback as all instruments are below threshold, so it is necessary to launch instruments enabling better techniques (more spectral bands in the visible and higher spatial resolution).

Land cover

Land cover is used for land utilization and composition mapping (e.g. the EC-agricultural monitoring project using MARS). The spatial coverage (observing cycle) and the time delay are optimum for almost all instruments. The horizontal resolution for all instruments is at least marginal or above the threshold. Measurement accuracy for all instruments is acceptable and are planned to be available for all future instruments.

Fires

The current capability for detecting fires with satellites is not acceptable. No instrument meets all requirements. The EOS AM-1 and PM-I, NOAA, and METOP satellites are or will be marginally meeting requirements for monitoring fires, but it is necessary to solve problems regarding data delay (EOS) and data accuracy (NOAA, METOP). Geostationary monitoring of fires (GOES-8) is showing promise and indicating that a trade-off between spatial and temporal resolution can be made.

Frost

The monitoring of frost conditions can be accomplished by remote sensing under clear sky conditions. Transient phenomena of this type require high frequency measurements (as high as every 15 minutes) with high horizontal resolution (better than 1 km). Geostationary satellites are optimum regarding frequency of observations (but they lack acceptable spatial resolution). Research polar satellites have adequate horizontal resolution (better than 100 m), but lack acceptable observing frequency. Currently monitoring frost by remote sensing can be obtained on large scales only. Local frost monitoring is not possible.

Soil moisture

Soil moisture is one of the most useful variables in agrometeorology. Optimum monitoring of soil moisture requires measurements to depths of 50-100 cm every 5-7 days, with horizontal resolution better than 100 m. Current active and passive microwave sensors determine soil moisture of upper few cm only with resolutions on the order of tens of meters for SAR systems and tens of kilometres for passive systems. Noting the usefulness of this parameter, even with the reduced resolutions of current measurements, some problems can be addressed.

Solar Insolation

Incoming solar radiation is measured by geostationary satellites at an acceptable level. Diurnal changes of clear and cloudy sky conditions offer useful input to agrometeorological models.

3.5.1 Summary of Agricultural Meteorology SOG

Regarding agricultural meteorology needs, it is concluded that:

- leaf area index and land cover measurements with higher spatial resolution are needed; the polar orbiting instruments should be enhanced to resolve sub 1 km features; and

- multifrequency synthetic aperture radar systems could offer significant improvements for canopy structure and water content determinations.

4. SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

4.1 Summary of RRR Demonstration

The RRR has been exercised for some WMO applications (NWP, synoptic meteorology, nowcasting, hydrology, and agricultural meteorology). Climate and ocean related issues are not addressed here; these programme areas will receive detailed consideration by other expert groups. The RRR has utilized a maturing database of satellite capabilities and user requirements. An objective critical review has produced evaluation charts. A subjective interpretation by satellite experts has generated statements of guidance in these applications areas.

4.2 Conclusions from RRR Demonstration

Several conclusions have been formed from RRR demonstration:

- the RRR process needs to be repeated periodically as the database matures through corrections and changes;

- the CR is sensitive to relatively small adjustments in the database of user requirements and satellite capabilities, these requirements and capabilities need further inspection by the 'Users' and 'Providers;

- the RRR has provided some useful insights in several different application areas; additional areas should be identified in coordination with the WMO. The addition of in situ observations with space-based observations also needs to be undertaken; and

- the RRR has indicated that satellite capabilities may be acceptable for satisfying user requirements for a given variable in one application area but not in another application area.

4.3 Conclusions about Satellite Capabilities

The SOGs reveal the following regarding about satellite capabilities in the five WMO programme areas:

* There is a continuing need in all applications areas for operational continuity of a suite of instruments deployed from at least two polar orbiting platforms and at least five geostationary platforms.

* NWP will benefit from the pending microwave enhancements of AMSU to the polar satellites (for a clear and cloudy sky sounding capability) and is awaiting high spectral resolution measurements from AIRS, IASI, and CrIS (for enhanced vertical resolution in clear sky soundings), planned for the 2000s. Measurement of wind profiles remains the most challenging (remote sensing lidar systems offer promise, but need the opportunity to mature). Variational data assimilation techniques suggest expansion of polar capabilities (such as increased vertical resolution soundings from high spectral resolution infrared systems and all sky soundings from microwave systems) to geostationary orbit would be very useful.

* Current satellite systems are unable to satisfy user requirements for synoptic meteorology simultaneously with those for nowcasting; at present, rapid small scale observations impede the regular larger scale observations. The timely delivery of satellite data and information to users remains a major challenge. Reliable precipitation estimates remain elusive. Both application areas have need of higher temporal and spatial resolution of measurements such as those to be offered by MSG in the next decade.

* Hydrology is anticipating some improvement in estimates of snow cover, snow water equivalent, and soil moisture from the experimental ADEOS-II and EOS microwave instrument (AMSR). Operational implementation of microwave capabilities and expansion of VIS/IR and TIR capabilities remain challenges for basin scale modelling of water and energy balances.

* Agricultural meteorology needs leaf area index and land cover measurements with higher spatial resolution; the polar orbiting instruments need to be enhanced to resolve sub 1 km features. Multifrequency synthetic aperture radar systems should be considered as they could offer significant improvements to canopy structure and water content determinations useful in this application area.

LIST OF ACRONYMS

ADEOS	Advanced Earth Observing Satellite
AIRS	Atmospheric Infrared Sounder
AMSR	Advanced Microwave Scanning Radiometer
AMSU	Advanced Microwave Sounder Unit
AVHRR	Advanced Very High Resolution Radiometer
CEOS	Committee on Earth Observation Satellites
CBS	Commission for Basic Systems
CR	Critical Review
CrIS	Cross track Infrared Sounder
EC	European Community
ENVISAT	
EOS	Earth Observing System
ERS	European Remote Sensing Satellite
EUMETSAT	European Organization for the Exploitation of Meteorological Satellites
GCOS	Global Climate Observing System
GOSSP	Global Observing System Space Panel
GTS	Global Telecommunication System
IASI	Infrared Atmospheric Sounding Interferometer
IR	Infrared
LAI	Leaf Area Index
METEOR	
METOP	Meteorological Operational Platform
MODIS	Moderate Resolution Imaging Spectrometer
MSG	Meteosat Second Generation
NDVI	Normalized Difference Vegetation Index
NOAA	National Oceanic and Atmospheric Administration
NPOESS	National Polar-orbiting Operational Environmental Satellite System

NWP	Numerical Weather Prediction
OKEAN	
RESURS	
RRR	Rolling Requirements Review
SOG	Statement of Guidance
SSMI	Special Sensor Microwave/Imager
TIR	Thermal Infrared
TIROS	Television Infrared Operational Satellite
TOA	Top of the Atmosphere
TOVS	TIROS Operational Vertical Sounder
TRMM	Tropical Rainfall Measuring Mission
VIS	Visible
WG-SAT	Working Group on Satellites
WMO	World Meteorological Organization

CGMS−XXVI WP−14
Prepared by Japan
Agenda Item : II/4

Examination of an Over-sampling Technique for the Imager of MTSAT

Summary and Purpose of Document

This document describes an overview of an examination of an over-sampling technique that would potentially improve the effective horizontal resolution of the MTSAT (Multi-functional Transport Satellite) Imager.

CGMS is requested to take note of the information on this document.

CGMS−XXVI WP−14

Prepared by Japan

Agenda Item : II/4

Examination of an Over-sampling Technique for the Imager of MTSAT

This working paper describes the summary of an examination of a technique that would potentially improve the effective horizontal resolution of MTSAT (Multi-functional Transport Satellite) Imager.

The IFOV (Instantaneous Field of View) of the MTSAT Imager is 4 km for the infrared channels. Two consecutive infrared images acquired by the MTSAT Imager whose imaging position are slightly offset each other can be processed to generate a 2 km-latticed (i.e. over-sampled) infrared image. And, it is further possible to generate an effective 2 km IFOV image by enhancing high spatial frequency of the 2 km-latticed image with the Digital Signal Processing technique.

Figure 1 shows an example of over-sampling and enhancement simulated using a NOAA-12 AVHRR infrared image that has 1.1 km resolution at

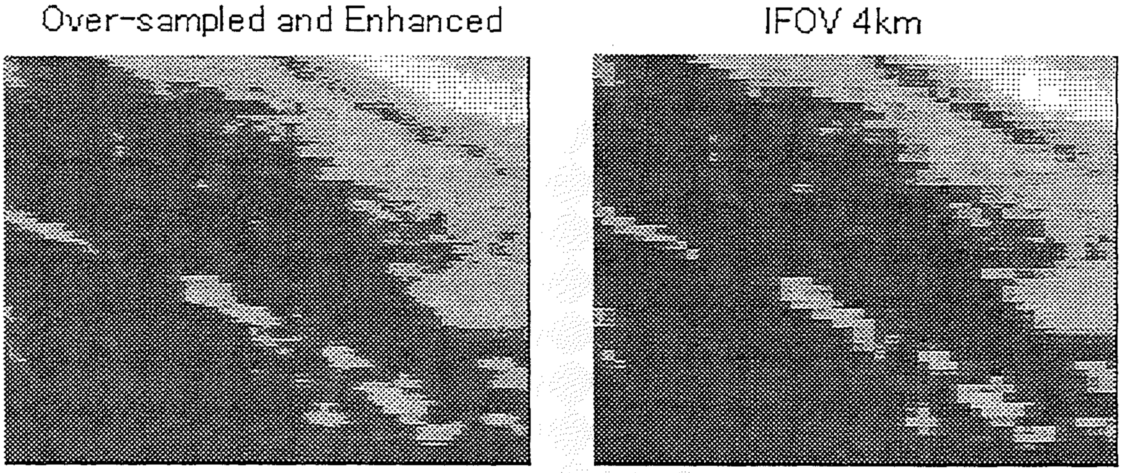


Figure 1 Example of Over-sampling and Enhancement simulated from NOAA-12 AVHRR Image

nadir. An over-sampled and enhanced image shows the details of clouds better than a 4 km IFOV image.

A preliminary on-orbit demonstration of the over-sampling imagery collection concept was conducted using the GOES-10 Imager during the spacecraft post-launch test period in October 1997. The GOES-10 data were used to develop and demonstrate the image analysis techniques for the study.

On-orbit tests for MTSAT Imager are scheduled from September through November 1999. During the tests, a few hundred over-sampling images with the size of 1000 km east/west and 500 km north/south will be acquired.

Reference

Kigawa, S., Sullivan, P., 1998: Study on Over-sampling for Imager, Meteorological Satellite Center Technical Note, No. 36, − (To Be Published)

Prepared for Meteorological Satellite Center
Technical Note No.36

Study on Over-sampling for Imager

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Abstract

This report describes the potential improvement of the effective ground resolution of MTSAT (Multi-functional Transport Satellite) Imager.

The IFOV (Instantaneous Field of View) of MTSAT Imager is 4 km for infrared and 1 km visible. A combination of some images acquired by the MTSAT Imager could generate 2 km-latticed infrared images. Furthermore, it is possible to generate an effective 2 km IFOV image by the enhancement of the 2 km-latticed image using Digital Signal Processing. This report also mentions the on-orbit demonstration of this concept.

1. Introduction

The purpose of this study is to demonstrate the effect of 2 km infrared imagery from on-orbit spacecraft. And the study is made on the premise that the existing instrument and ground system should be put to use to minimize the cost and risk of improvement. The design modification of the MTSAT Imager and ground image processing system for this study is not required.

This report describes the MTSAT spacecraft and Imager design, a method of image combination, a technique of image enhancement, and an approach to on-orbit demonstration.

2. MTSAT and Imager

The MTSAT spacecraft configuration, shown in Figure 1, is a three-axis, body-stabilized design capable of continuously pointing the optical line of sight of the Imager to the earth. The use of a single-wing solar array configuration allows the passive north-facing radiation cooling of the Imager. A solar sail and trim tab provide the fine balance control of the solar radiation pressure.

The Imager consists of Sensor Module, Power Supply Module, and Electronics Module. The Sensor Module contains the telescope, scan assembly, detector, thermal louver, and passive radiant cooler. Figure 2 shows a schematic appearance of the Sensor Module.

The Imager contains a servo-driven, two-axis gimballed scan mirror. The position and size of a scan area are controlled by command from the ground system, and so the Imager is capable of various image sizes. The scan start position of a scan area is specified by 8 micro-radians (0.28 km) in the north/south direction and 16 micro-radians (0.57 km) the east/west.

Ground sampling distance, shown in Figure 3, is 112 micro-radians (4 km) in the north/south direction and 64 micro-radians (2.3 km) the east/west for infrared imagery.

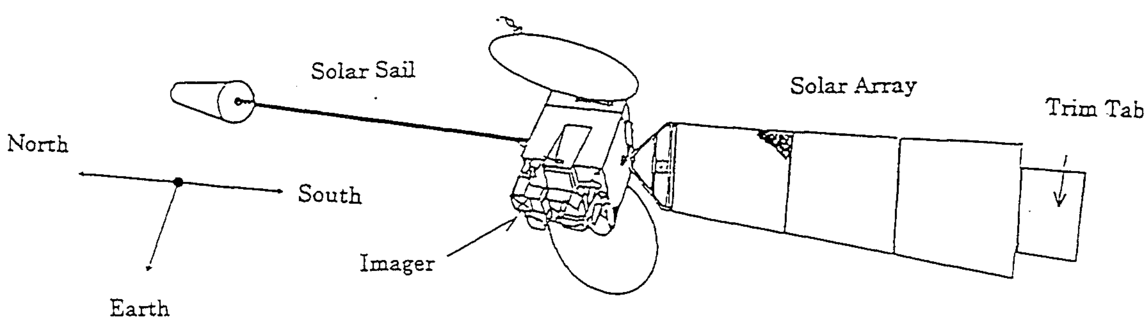

Figure 1 MTSAT On-orbit Configuration

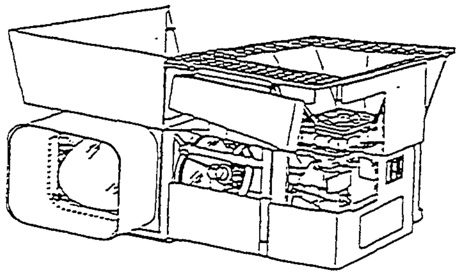

Figure 2 . Imager Sensor Module

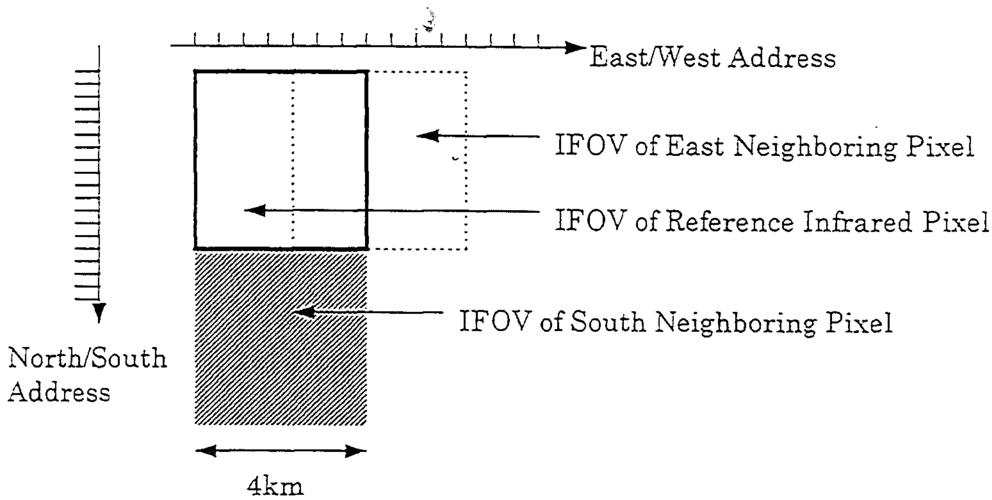

Figure 3 Infrared Pixel and Address

3 . Over-sampling Imagery

A large overlap area between two neighboring pixels is generated in the east/west direction because the IFOV size of infrared channels is 4 km while the ground sampling distance is 2.3 km. This kind of imagery, which is sampled by a narrower distance than the IFOV size is called "over-sampling imagery" in this report. There is normally no over-sampling in the north/south direction for the MTSAT Imager because the IFOV size and the north-south step size are both 4 km.

Conceiving of the over-sampling imagery in the frequency domain helps to understand what it means. Figure 4 shows Modulation Transfer Function (MTF) in the north/south and east/west. An east-west image signal is band-limited less than the Nyquist frequency because the signal is over-sampled. On the other hand, the absence of over-sampling in the north/south direction provides response in higher frequency than the Nyquist frequency. Thus, aliasing appears in a north/south image signal and it is not possible to reconstruct an original image signal.

Now if an image is over-sampled in the north/south direction, the Nyquist frequency of the north/south moves to higher frequency and the aliasing is solved. Thus, it is possible to convert the IFOV (i.e. Point Spread Function) using the Digital Signal Processing.

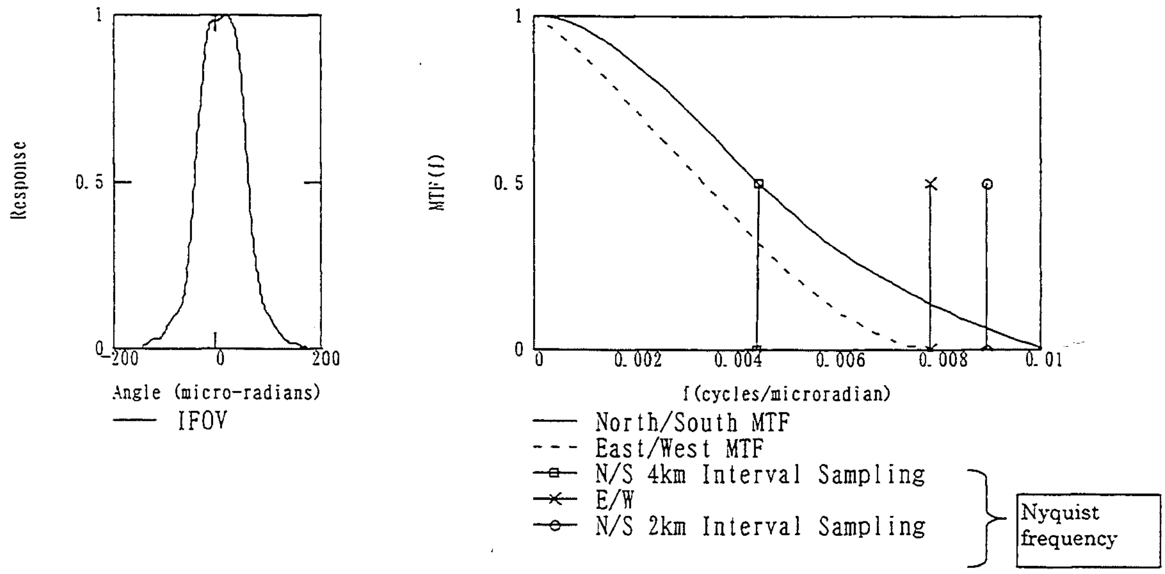

Figure 4 Imager MTF and PSF

The over-sampling image is generated by a combination of two images simply. As mentioned above, the scan start position of an image in the north/south direction is specified by 8 micro-radians. Here, it is proposed to acquire a serious of two images; the position and size of the second image is the same as the first image except for a north/south scan start position offset. The difference of the north/south scan start positions is a half infrared pixel (i.e. 56 micro-radians). Then incorporating the first image with the second alternately, shown in Figure 5, generates the over-sampling image.

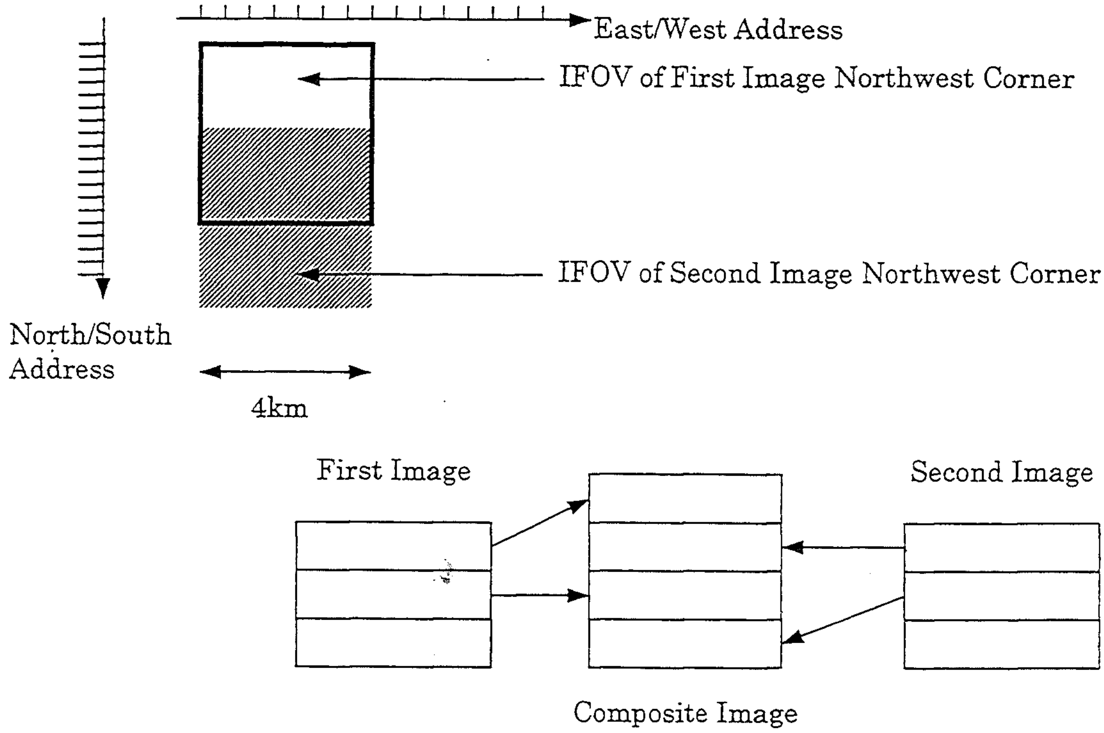

Figure 5 Generation of Over-sampling Imagery using MTSAT Imager

4. Filter for Enhancing

The digital filter that is used for enhancing the over-sampling image is generated by the ratio of a 2 km-IFOV MTF to a 4 km-IFOV MTF. Figure 6 shows the process of making the filter.

5. Verification by AVHRR Image

The filter for enhancing was verified using AVHRR images. A 2 km IFOV image and 4 km IFOV image are simulated by the AVHRR infrared image that has 1.1 km resolution at nadir for the verification of the effect of the enhancing filter.

Figure 7 shows the flow of the verification. Squares (□) in the figure show the size of IFOV, small dots (・) mean the sampling points of a 1 km image, and circles (●) the sampling points of a 2 km image. The over-sampling image has 4 km IFOV and is enhanced by the 2 km to 4 km MTF ratio filter (Operator C shown in Figure 8) described above.

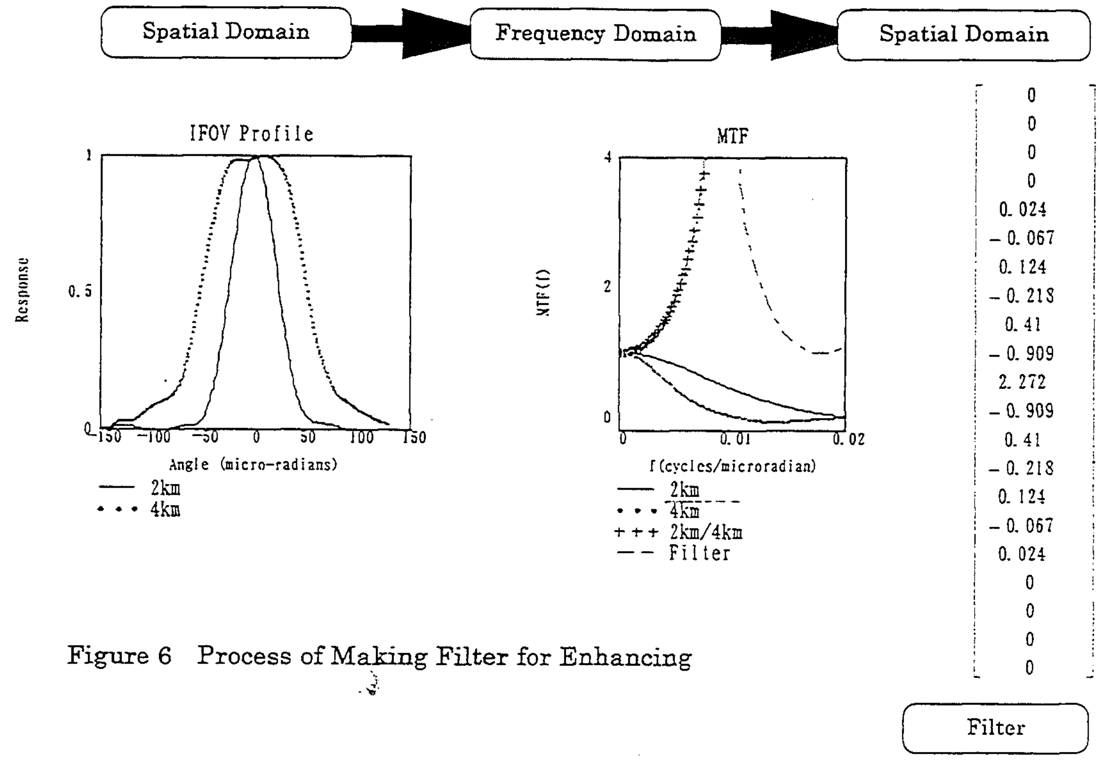

Figure 6 Process of Making Filter for Enhancing

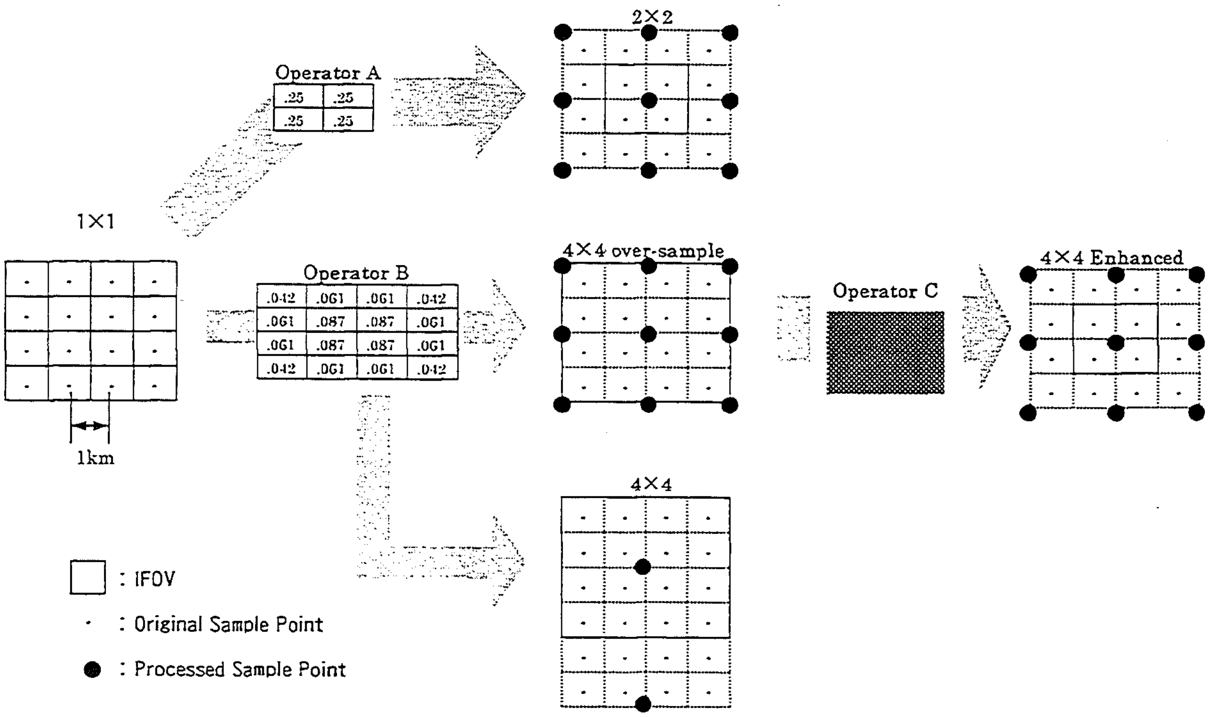

Figure 7 Verification Flow using AVHRR Image

Operator B (1×1=>4×4)

0.042	0.061	0.061	0.042
0.061	0.087	0.087	0.061
0.061	0.087	0.087	0.061
0.042	0.061	0.061	0.042

Operator C (4×4=>2×2)

0.004	-0.005	0.008	-0.012	0.020	-0.036	0.106	-0.036	0.020	-0.012	0.008	-0.005	0.004
-0.005	0.008	-0.012	0.018	-0.029	0.053	-0.155	0.053	-0.029	0.018	-0.012	0.008	-0.005
0.008	-0.012	0.018	-0.027	0.043	-0.078	0.229	-0.078	0.043	-0.027	0.018	-0.012	0.008
-0.012	0.018	-0.027	0.040	-0.065	0.119	-0.348	0.119	-0.065	0.040	-0.027	0.018	-0.012
0.020	-0.029	0.043	-0.065	0.104	-0.191	0.560	-0.191	0.104	-0.065	0.043	-0.029	0.020
-0.036	0.053	-0.078	0.119	-0.191	0.351	-1.028	0.351	-0.191	0.119	-0.078	0.053	-0.036
0.106	-0.155	0.229	-0.348	0.560	-1.028	3.007	-1.028	0.560	-0.348	0.229	-0.155	0.106
-0.036	0.053	-0.078	0.119	-0.191	0.351	-1.028	0.351	-0.191	0.119	-0.078	0.053	-0.036
0.020	-0.029	0.043	-0.065	0.104	-0.191	0.560	-0.191	0.104	-0.065	0.043	-0.029	0.020
-0.012	0.018	-0.027	0.040	-0.065	0.119	-0.348	0.119	-0.065	0.040	-0.027	0.018	-0.012
0.008	-0.012	0.018	-0.027	0.043	-0.078	0.229	-0.078	0.043	-0.027	0.018	-0.012	0.008
-0.005	0.008	-0.012	0.018	-0.029	0.053	-0.155	0.053	-0.029	0.018	-0.012	0.008	-0.005
0.004	-0.005	0.008	-0.012	0.020	-0.036	0.105	-0.036	0.020	-0.012	0.008	-0 005	0.004

Operator(Operator B * Operator C)

0.014	-0.023	-0.049	-0.049	-0.023	0.014
-0.023	0.039	0.083	0.083	0.039	-0.023
-0.049	0.083	0.176	0.176	0.083	-0.049
-0.049	0.083	0.176	0.176	0.083	-0.049
-0.023	0.039	0.083	0.083	0.039	-0.023
0.014	-0.023	-0.049	-0.049	-0.023	0.014

Operator A (1×1=>2×2)

0	0	0	0	0	0
0	0	0	0	0	0
0	0	0.25	0.25	0	0
0	0	0.25	0.25	0	0
0	0	0	0	0	0
0	0	0	0	0	0

Figure 8 Filter for Enhancing (Operator C)

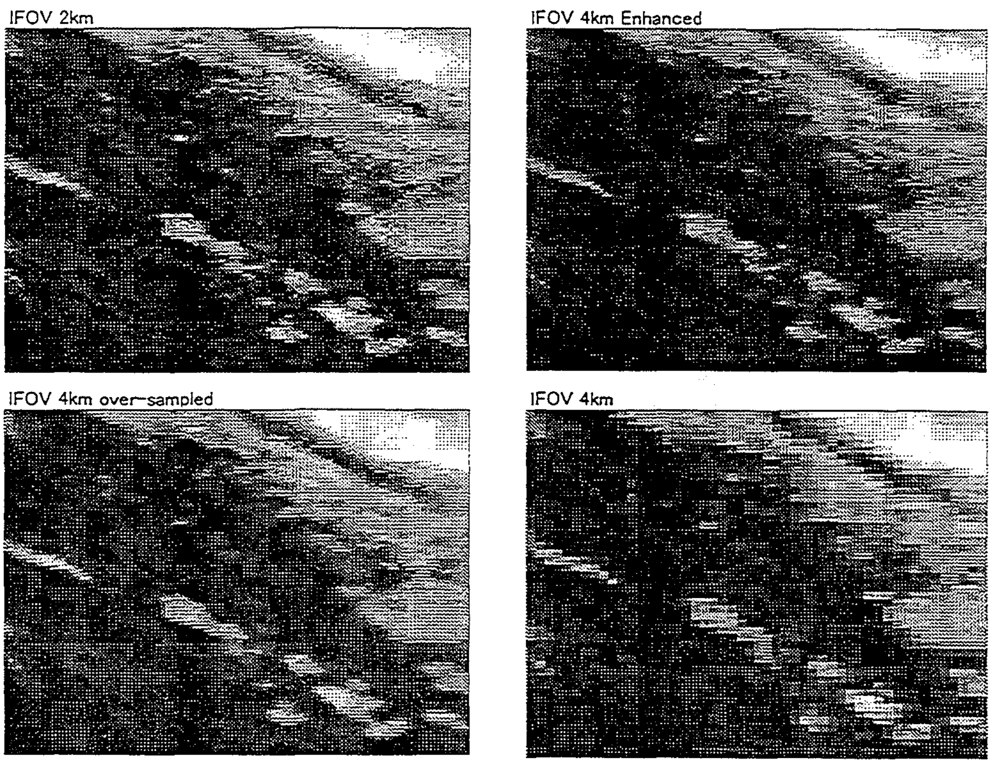

Figure 9 Simulation Results using AVHRR Image

Figure 9 shows simulation results as images. The over-sampling image shows the details of the clouds better than the original image due to the over-sampling image has having four times as many pixels as the original. Brightness level on the enhanced image is like that on the 2 km IFOV image, verifying that the enhancing filter has been generated successfully.

6. Cloud Motion Impact

Two or more images produce the over-sampling image. It is unavoidable to have a time lag of scanning between these source images, and the time lag has an impact on the over-sampled, composite image. The cloud motion caused by the time lag should be considered in the process. Now the cloud motion is considered using one-dimensional discussion.

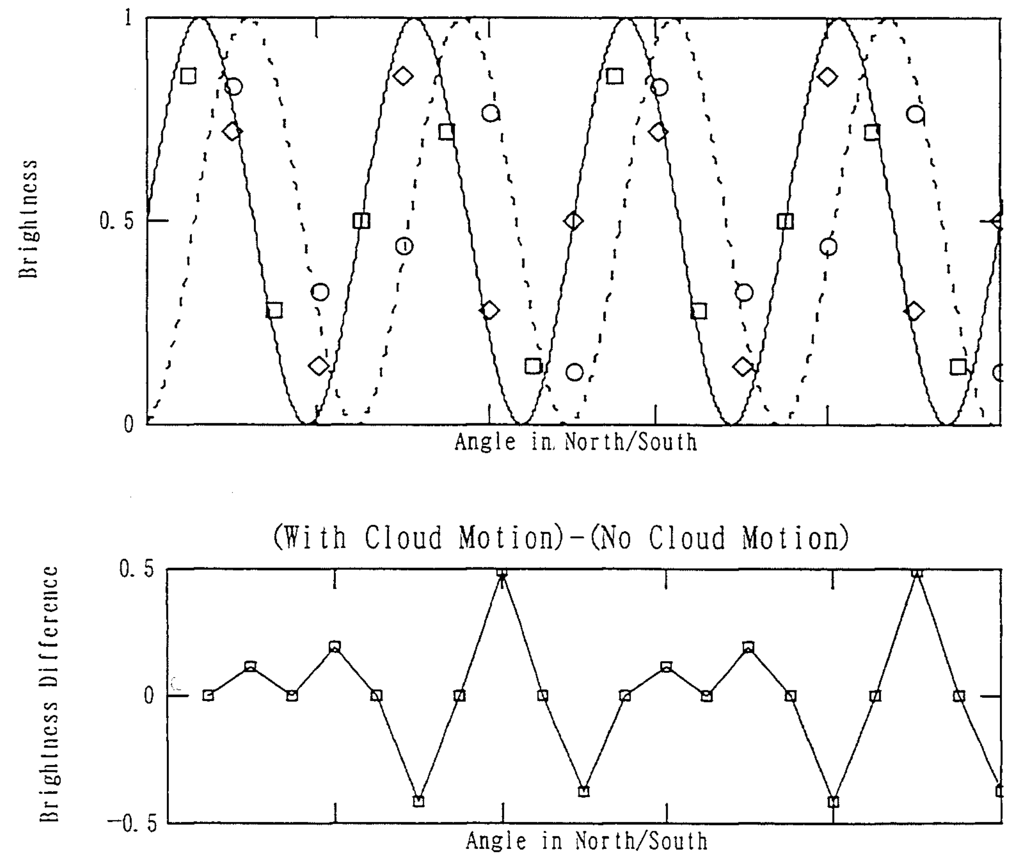

Figure 10 Example of Error due to Cloud Motion

Figure 10 shows the north/south brightness level of the over-sampling image that is generated by two source images. The source images are observed by a rectangular IFOV. On the upper graph, a solid line shows input (i.e. cloud pattern) for the first image, and a dotted line for the second. Squares (□) mean the brightness of the first image, circles (○) the second image. If there should be no change of the cloud pattern between these images, the second image appears with diamonds (◇) . On the lower graph, the difference of the brightness between the over-sampling image with a change of the cloud pattern (i.e. cloud motion) and that without the cloud motion is shown. This shows that an error from the Nyquist frequency through 1/2 Nyquist frequency is generated on the over-sampling image if the cloud motion appears. The error is enhanced by the enhancing filter, and causes a marked stripe in the north/south direction. Thus, a low-pass filter is required to eliminate the stripe generated by the cloud motion.

7. On-orbit Demonstration

MTSAT will be launched in geostationary orbit around August 1999. On-orbit testing for the Imager is scheduled from September through November 1999. During the testing, the over-sampling image will be acquired for the verification of image navigation accuracy. A few hundreds of the over-sampling images have the size of 1000 km east/west and 500 km north/south will be available for the navigation verification and an assessment of the cloud motion wind.

8. GOES-10 On-orbit Demonstration

A preliminary demonstration of the over-sampling imagery collection concept was conducted using the GOES-10 Imager during the spacecraft post-launch test period in October 1997. The GOES-10 Imager provides a valid proof-of-concept because its IFOV and scan system design is identical to that of the MTSAT Imager.

The GOES-10 test produced imagery oversampled in the east-west direction by the nominal 2.3 km sampling interval to 4 km IFOV ratio.

Over-sampling in the north-south direction was accomplished by collecting a series of three images that together produce a composite image with 2 km north-south sampling. The first image was a 1000 km (east-west) by 250 km (north-south) image. The second was a 1000 km by 500 km image offset from the first image by 2 km (one-half pixel) in the north-south direction. The last image was a 1000 km by 250 km frame with its north-south start address equal to the stop address of the first frame.

Together the first and third images produce a 1000 km by 500 km image that is offset from the second image by a half pixel. By collecting two 1000 km by 250 km images (instead of a 1000 km by 500 km frame), the effect of cloud motion is minimized because less time has elapsed between the collection of the first image and the top half of the second image and also between the bottom half of the second image and the third.

This image sequence was repeated at three different geographical locations in order to provide a variety of image content. The GOES-10 data was used to develop and demonstrate the image analysis techniques presented here.

9. Conclusion

The essence of this study is the use of an existing imaging system to demonstrate the effect of 2 km infrared images. The study has established a method of making the enhancing filter, a technique of making the over-sampling image, a procedure of image acquisition, and so on. Testing environment such as image processing software will be prepared for the on-orbit demonstration after this.

CGMS-XXVI
PRC WP-08
Agenda Item: II/2

The Preliminary Research on the In-Flight Relative Calibration of FY-2 Satellite Scan Radiometer

1. Introduction

The multichannel scan radiometer of FY-2 geostationary meteorological satellite has three spectral channels: visible channel (0.5-1.05μm), infrared channel (10.5-12.5μm) and water vapor channel (6.2-7.6μm). In the normal condition the FY-2 satellite observes the Earth at every half hour interval and obtains the earth image of three channels. In order to make further use of the image to produce numerical products such as sea surface temperature, cloud parameter, wind vector and OLR, as well as to extend the field of quantitative applications, it is necessary to perform absolute calibration to the image. FY-2 satellite is a spin stabilization satellite, due to the limitation of observing method only in-flight relative calibration can be used. Using the result of pre-launch laboratory calibration, the transferring of relative calibration to the absolute calibration can be accomplished in some extents but it's precise is limited. Inter-satellite relative calibration(or cross calibration) and field calibration are the good approaches to improve the precise. Researchers in the National Satellite Meteorology Center have studied FY-2 relative calibration with both GMS-5 satellite and NOAA-14 satellite and experiments on FY-2 satellite IR channel have been done.

2. Relative Calibration of FY-2 IR channel with GMS-5

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

2.1 Spectral correction

GMS-5 satellite's VISSR IR channel is much different to that of FY-2

CGMS-XXVI
PRC WP-08
Agenda Item: II/2

The Preliminary Research on the In-Flight Relative Calibration of FY-2 Satellite Scan Radiometer

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Summary

This paper describes the preliminary research on the in-flight relative calibration between FY-2A and GMS/NOAA

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satellite, it adopts split window channel with two IR channels : IR1(10.5-11.5μm) and IR1(11.5-12.5μm). It is inevitable to cause variation in observations due to the difference in spectral characteristic. In order to complete relative calibration, spectral correction is required. Based on LOWTRAN-7 radioactive transfer code and with numerical simulating calculation, the spectral correction model is as following:

$$R_F = f(R_G),$$

namely, building spectral correction equation that transforms corresponding observations of GMS-5 to that of FY-2 satellite, for example, using linear correction model.

one channel relative calibration with CGMS-5 IR1

$$R_F = a_1 + b_1 R_{IR1} \qquad (1)$$

one channel relative calibration with CGMS-5 IR2

$$R_F = a_2 + b_2 R_{IR2} \qquad (2)$$

two channels relative calibration with CGMS-5 IR1 and IR2

$$R_F = a_3 + b_3 R_{IR1} + c_3 R_{IR2} \qquad (3)$$

where R_F is spectral corrected observations of FY-2 IR channel, R_{IR1} and R_{IR2} are for GMS-5 IR split window observations, a, b and c are coefficient of the correction equation obtained by numerical calculation.

2.2 Observations matching

The most important point in assuring calibration precise is the match of observations of two kind of satellites. The data must be observed simultaneously at the same target and in similar geometric condition.

(1) Time matching

In the normal condition, FY-2 observes the Earth at the first half hour and GMS-5 at the latter half hour. In need of satellite wind observation, four additional observations are added which can provide simultaneously observation of the two satellites so time matching is satisfied.

(2) Pixel matching

Based on image geographic location of two satellites, the same target and then the observation is ensured. Considering errors in location we enlarges the size of collocated target in the proceeding. Generally the collocated target consists of 5*5 pixels. To ensure the uniformity of targets, uniform cloud, open ocean or desert are selected as targets and uniformity validation is required (for example, in target region the variation of image digital counts is less than 2 counts.)

(3) View angle matching

Different view angles (nadir of satellite) correspond to different length of atmospheric path, which would lead to variation of satellites' observations, so in the relative calibration iso-view angle matching must be take into account. As FY-2 satellite locates at $105^0 E$ over the equator and GMS-5 at $140^0 E$, the iso-view angle in overlapped observing region is near $122.5^0 E$. If we adopt the matching region between +5 to -5 in longitude, then the match region of iso-view angle is between $117.5^0 E$ to $127.5^0 E$.

In terms of the data matching methods mentioned above, we can complete data sampling of the collocated targets with IR image pairs from two satellites and generate targets sampling data set through spectral correction for relative calibration, which can be serve as basic data for relative calibration.

2.3 Relative calibration model

Relative calibration model is divided into two categories: direct calibration model and indirect calibration model.

(1) direct calibration model

The relationship of calibration is set between GMS-5 radiance values obtained from the spectral corrected matching data set and FY-2 satellite's match counts. It is as:

$$R_F = \alpha + \beta C \tag{4}$$

where R_F is FY-2 satellite's radiance computed from corresponding spectral corrected GMS-5 radiance, c is FY-2 satellite's digital counts, and A ,B are the relative calibration coefficients obtained by regression from the match data set.

(2) indirect calibration model

Based on in-flight calibration, the relative deviation correction is done with the collocated data set, the equation is:

$$R_F = MR_F^0 = M(I + KC) \tag{5}$$

where R_F is similar to equation (4), R_F^0 is FY-2's radiance obtained by in-flight calibration, I and K are in-flight calibration coefficients. C is the match counts of FY-2 satellite. M is relative calibration coefficient which can be used as the average of multi-data.

3. IR channel relative calibration of FY-2 and NOAA-14 satellites

3.1 Spectral correction

NOAA polar orbit meteorological satellite's AVHRR IR split window channels are similar to that of GMS-5. When using for the relative calibration of FY-2's IR channel, its spectral correction model is similar to that of GMS-5. The only difference of them is in the specific spectral response function, which leads to different regression coefficients in spectral correction .

3.2 Observation matching

(1) Time matching

FY-2 and NOAA-14 satellites have different kind of orbits. NOAA-14 is a sun synchronous orbit satellite, it passes each point in the Earth only twice every day. While FY-2 satellite has much more observations, we can select the nearest times (within about half an hour) for the time matching.

(2) Pixels matching

The method of pixel matching is similar to that of GMS-5, the difference is only due to NOAA-14 AVHRR has a higher resolution(1.1 km at sub-satellite point). In order to ensure the proper size of matching region, pixels of selected collocated target need to be increased to 25*25. Furthermore, quantization level of NOAA is 10 bits, so in targets uniformity validation the threshold of digital counts should be relaxed.

(3) View angle matching

NOAA-14 is polar orbit meteorological satellite, its observing method of the radiometer is much different to that of FY-2 satellite, the scanning direction is vertical to the orbit. Its equal view angle is a strip paralleling to the orbit, which is much different to the concentric circles of geostationary meteorological satellite. So the match region of equal view angle is complicated. In the match process of view angle, the region of +5 to -5 is acceptable.

3.3 Relative calibration model

We also use direct or indirect calibration models, which are similar to equation (4) and (5) but have different coefficients. Because NOAA IR channel can reach the absolute calibration of a precise about 1K, to use NOAA satellite to calibrate FY-2 IR channel can get higher precise than using GMS-5.

4. Experiment results and analysis

(1) Results of spectral correction

Based on LOWTRAN-7 radioactive transfer code, 100 kinds of different atmosphere and surface status are selected. Then spectral correction coefficients are gotten by simulated calculation, the result is listed in table 1. If using equivalent brightness temperature difference (NEΔT) to evaluate the correction value, it turns out that the results of three correction mode is similar. For mid-latitude atmosphere, the difference of equivalent brightness temperature is less than 0.5K, but for tropical atmosphere with high water vapor content, it is >1.0K and the largest value is up to 3K.

Table 1 Coefficients of spectral correction equation for relative calibration

satellites	channels	a	b	c
FY-2 and NOAA-14 satellites	FY-2 IR via NOAA-14 4 channel	4.333540	1.032214	
	FY-2 IR via NOAA-14 5 channel	-5.378635	0.9847692	
	FY-2 IR via NOAA-14 4, 5channels	-0.03529016	1.090899	-2.818277e-3
FY-2 and GMS-5 satellites	FY-2 IR via GMS-5 IR1	3.99726	1.028553	
	FY-2 IR via GMS-5 IR2	-0.7151459	0.9763711	
	FY-2 IR via GMS-5 IR1 and IR2	-0.01675608	1.082054	-2.683168e-3

2. Using direct calibration model, relative calibration equation of FY-2 and NOAA-14 is set up, the calibration coefficients are listed in table 2. With preliminary validation, the calibration precise is about 2K.

Table 2 Coefficients of FY-2 and NOAA relative calibration

satellites	channels	α	β
FY-2 and NOAA-14 satellites	FY-2 IR via NOAA-14 4 channel	195.9254	-0.7973201
	FY-2 IR via NOAA-14 5 channel	191.3888	-0.7913221
	FY-2 IR via NOAA-14 4, 5 channel	201.8869	-0.8403938

Note: The unit of radiance R_F is $mw/(m^2.sr.cm^{-1})$

3. The relative calibration precise is related to the status of in-flight satellite. In general the temperature in satellite cabin is stable, only with litter changes especially without any obvious variations in 24 hours. Under this situation the relative calibration can be used for a longer period. But around equinox, because of the effect of eclipse there are rapidly temperature variations in satellite, the relationship for radiometer calibration will be changed, it will affect the calibration precise. At this time we should increase times of calibration, or use indirect calibration model. On the basis of in-flight satellite calibration to correct system deviation by relative calibration.

PROGRAM FOR INTERCALIBRATION OF GMS, GOES, AND METEOSAT, VERSUS HIRS AND AVHRR INFRARED RADIANCES

Summary and Purpose of this document:

Action Proposed:
None

CGMS-XXVI USA-WP-21
Prepared by: USA
Agenda Item: III.3

PROGRAM FOR INTERCALIBRATION OF GMS, GOES, AND METEOSAT, VERSUS HIRS AND AVHRR INFRARED RADIANCES

INTRODUCTION

CGMS members have been investigating various approaches for intercalibration of different sensors on different platforms (Gube and Schmetz, 1997; Wanzong and Menzel, 1997). This paper reports on a CGMS member collaboration toward defining techniques for cross-calibration of all the geostationary and polar orbiting sensors. Initial focus is on comparing the infrared window radiances measured by these systems; the goal is calibration within 1 K for IR and WV bands.

There are many aspects of the data that need to be considered when an intercalibration of two sensors is considered. The following list mentions some of the more obvious ones:

- measurements from the two sensors must be collocated in space and time
- spectral response differences must be accounted for
- spatial resolution differences must be considered
- viewing angle differences must be minimized
- day night differences in the calibration must be investigated
- cloud contamination of the radiances must be considered
- scene uniformity must be considered
- statistical significance of the sample must be adequate

These aspects of the intercalibration are handled in various ways from one algorithm to another.

2. CGMS XXV PROGRAM

At CGMS XXV, it was agreed that designated CGMS members should collect data sets with overlap between a polar orbiting sensor (HIRS or AVHRR) and some of the geostationary imagers (GMS, Meteosat, and GOES). Data sets include the spectral response functions of the IR and WV bands and the atmospheric state at the time of the intercomparison (surface temperature, atmospheric temperature and moisture profiles, T(p), and q(p)). Each participant processed one or more intercalibration data sets with their preferred algorithm.

3. ACTIVITY AT EUMETSAT

EUMETSAT has developed a satellite intercalibration technique and applied it to measurements from the Meteosat-6 IR window, the NOAA-14 AVHRR split window (channels 4 and 5), and the GOES-8 imager IR window (channel 4). An agreement within 1-2% for the calibration coefficients is found, which translates to uncertainties of about 1-2 K for typical sea surface temperatures. This is comparable to results from other vicarious calibration techniques.

The method is detailed in paper EUM WP-18 to be presented at CGMS XXVI. It will also be used in the operational processing of future meteorological satellites supported by EUMETSAT, as it will be added to the existing vicarious calibration methods based on radiative transfer models. This will further increase the capability to monitor calibration and contribute to the international efforts to arrive at a compatible calibration of similar satellite sensors onboard different spacecraft.

4. ACTIVITY AT MSC/JMA

MSC has made progress in the intercalibration performance of the infrared window on GMS-5 (IR sub-satellite resolution is 5 km) and NOAA-14 (IR sub-satellite resolution is 4 km for GAC). Using the intercalibration approach described in the USA WP-16 of CGMS XXV, six cases have been studied. Data are selected for intercomparison when

- the observational time difference between GMS-5 and NOAA-14 is within 30 minutes in the daytime to reduce variability of meteorological conditions and to enhance removal of cloudy pixels using visible data.

- clear sky over ocean near nadir views within 10 degrees from sub-satellite point of both satellites are used to minimize the atmospheric effect due to differences of observational path and zenith angles, cloud contamination, and surface non-uniformities.

The selected region is subdivided into grid areas (0.25 latitude x 0.25 longitude) and the brightness temperatures corresponding to the clear part of every sub-grid area are extracted by a histogram technique to minimize the effect due to the difference in spatial resolution between GMS-5 and NOAA-14. The warmest brightness temperatures corresponding to 50% of the accumulated frequency in every sub-grid area are averaged and that average is designated as the representative clear sky value for that sub-grid area. The average brightness temperature of all the sub-grid averages for each satellite is then compared.

For 6 days in early December 1997, MSC found GMS-5 to be colder by about 1.2 C than NOAA-14 AVHRR with a scatter of about 0.2 C. MSC found that there was no need for a correction near nadir for any atmospheric effect due to spectral response differences. LOWTRAN 7 calculations revealed differences less than 0.01K for view angles within 10 degrees from sub-satellite point.

MSC is comparing AVHRR ch.5 (12 microns) of NOAA-14 and IR-2 (12 microns) of GMS-5 and will report the results at CGMS XXVI.

5. ACTIVITY AT NESDIS

A USA WP describes the NESDIS approach for calibrating geostationary sensors with respect to a polar orbiting sensor. Radiances from both sensors with near nadir view of a scene containing mostly clear but also some cloudy skies are averaged to 100 km resolution. 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. Three comparisons were made between each leo and geo sensor. Initial results suggest that the infrared window sensors on GOES-9 and GMS-5 are in good agreement (within 0.5 C) with NOAA-14 HIRS and AVHRR, while GOES-8 appears to be 1.2 C warmer than HIRS and 0.6 warmer than AVHRR.

6. CONCLUSION

Intercalibration of the polar orbiting and geostationary satellite systems is necessary for consistency of data sets involving more than one sensor. Within the lifetime of one sensor, there is a need to determine fluctuations associated with the seasonal cycle for the spinning geostationary sensors (such as Meteosat, GMS, and GOES-VAS), with the diurnal and seasonal cycle for the three axis stable geostationary sensors (such as GOES-IJKLM, GOMS, and MTSAT), and with the day-night cycle for the polar orbiting sensors (such as NOAA, METOP, and NPOESS); each affects the temperature regime aboard the respective platform. For climate or trend analyses, all temporal transitions from one sensor to another (e.g., GOES-6 to GOES-7) should be covered with an independent sensor (e.g., NOAA-10). The community of satellite operators needs to begin a program to intercalibrate their current sensors; when individual sensors overlap in space and time, intercalibration reduces the calibration uncertainty. CGMS members are making good progress toward such a program. This work must be continued and expanded to other parts of the spectrum (e.g. water vapor bands, visible bands).

7. References

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Prepared by: USA
Agenda Item: II.3

GOES TEMPERATURE AND MOISTURE SOUNDINGS IN 1997

Summary and Purpose of this document:

Action Proposed:
None

CGMS-XXVI USA-WP-17
Prepared by: USA
Agenda Item: II.3

GOES TEMPERATURE AND MOISTURE SOUNDINGS IN 1997

INTRODUCTION

The GOES-8/9 sounders continue to produce operational soundings every hour over North America and nearby oceans. Atmospheric temperature and moisture profiles are generated using a simultaneous physical retrieval algorithm. During the past year, GOES-10 was tested, the resolution of the soundings was increased from 50 km to 30 km, the cloud mask was improved, and moisture retrievals were used operationally in the Eta model.

2. SOUNDING ALGORITHM AND PERFORMANCE

Since July 1995, the National Environmental Satellite, Data, and Information Service (NESDIS) has been producing operational hourly GOES-8 temperature and moisture soundings over the continental United States, the western Atlantic Ocean, and the Gulf of Mexico. Hourly GOES-9 soundings over the eastern Pacific Ocean and the western United States have been added since February 1996. Retrievals in clear regions typically have a separation of about 50 kilometers, depending on cloud cover. Between 2000 and 3000 retrievals are made each hour. The two GOES sounders provide 24 times the number of soundings over North America that are available from polar orbiters and 150 times those available from radiosondes.

Clear sky vertical temperature and moisture profiles (including surface skin temperature) are determined at 40 pressure levels from 1000 to 0.1 hPa using a simultaneous physical retrieval algorithm (Smith, 1983; Hayden, 1988; Ma et al., 1998). Also, estimates of surface temperature and cloud pressure and amount are obtained as by-products. The processing involves several steps: a) identify clear versus cloudy FOVs by intercomparing brightness temperatures in adjacent CO2 channels and comparing the window channel to surface observations (Hayden, et al., 1998); b) establish a first guess by performing radiative transfer calculations using a National Centers for Environmental Prediction (NCEP) numerical model forecast (6 to 18 hour) and surface observations as boundary conditions; c) average radiances for the clear sky FOVs within the sounding processing area and apply a radiance bias adjustment; d) perform a simultaneous physical retrieval of temperature and moisture profile deviations from the first guess for clear FOVs and assign retrieval location to the mean position of the clear FOVs; and e) determine cloud top properties for all cloudy FOVs.

The comparison of GOES retrievals to radiosonde measurements or numerical model profiles is not ideal due to differing measurement characteristics (point versus volumetric), co-location errors (matches are restricted to 0.25 degrees), time differences (within one hour), and radiosonde errors (Schmit, 1996). However, this method has become the standard approach for GOES sounding validation. A study of the GOES retrievals for one year (April 1997 to March 1998) indicates that they are more accurate than the NCEP Eta model operational short-term, regional forecasts, for both temperature and moisture, even in the vicinity of the radiosonde where they must necessarily be verified.

Table 1 shows a comparison of layer means of moisture as well as atmospheric stability between GOES, the current NCEP forecast first guess (from the Eta model), and radiosonde determinations. Since the GOES sounder measures moisture content over broad layers in the troposphere, it is more meaningful to compare layer mean and total column values rather than single level values. The total column water vapor RMS difference with respect to radiosondes for this twelve month period in 1997-98 has been reduced from 3.4 mm for the forecast first guess to 3.0 mm for the GOES retrievals, roughly an improvement of 10%. It is found that GOES improves the layer mean values by 0.1 to 0.2 mm in each layer.

More significant is the fact that much larger differences (greater than 100%) between GOES soundings and model forecasts often occur over oceanic regions where radiosondes are unavailable; this indicates a much larger potential for GOES soundings to influence the forecast model in data sparse regions.

Table 1. Comparison of moisture (mm) and atmospheric stability (deg C) retrievals April 1997 to March 1998 of the Eta model first guess and the GOES retrievals with respect to radiosonde determinations. Collocation is within 0.25 degrees. Bias and root mean square (RMS) scatter about bias are indicated. Sample size is 2363. Sigma levels are pressure divided by surface pressure.

	Eta Guess		Retrieval	
	Bias	RMS	Bias	RMS
Total Water Vapor	-1.1	3.4	-1.5	3.0
WV1 (Surface to .9 sigma)	-0.4	1.5	-0.5	1.4
WV2 (0.9 to 0.7 sigma)	-0.4	2.0	-0.6	1.7
WV3 (0.7 to 0.3 sigma)	-0.3	1.2	-0.4	1.0
Lifted Index	-0.4	2.4	-0.6	2.2

The atmospheric stability inferred from these twelve months of profiles has also been evaluated. GOES lifted indices (LI) of air parcels elevated to 500 hPa are found to be less stable in the mean by 0.6 C than those inferred from radiosondes with an RMS difference of 2.2 C. The numerical model first guess is 0.4 C less stable in the mean and shows an RMS difference of 2.4 C with respect to radiosonde determinations. In the vicinity of radiosondes, the GOES depiction of atmospheric stability is improving upon the first guess information from the forecast model.

In December 1997, the size of a sounding processing box was reduced from a 5x5 FOV array to a 3x3 FOV array to keep the spatial scale of the retrievals and that of the numerical models commensurate at roughly 30 km. This increased the product resolution of both the retrievals and the cloud information. Radiosonde co-location statistics for GOES-8 show the 3x3 retrievals are slightly improved compared to the 5x5 retrievals. The bias was reduced by 0.1 mm for 243 radiosonde matches.

During the fall of 1997, the cloud clearing subroutine was enhanced. Several additional checks were incorporated to make the identification of cloud more accurate. The changes included: rejecting the profile retrieval if the cloud-cleared IR window brightness temperature value is 1.5 C colder than the calculated value from the forecast first guess (with the sea surface temperature), ignoring the visible check over elevated mountainous terrain, and relaxing the 13.3 micron cloud-clearing check (gradients less than three times detector noise are tolerated in clear 3x3 regions).

3. Derived Product Images

An effective display of the sounding information is the derived product image (DPI) wherein a product such as total column precipitable water vapor (PW) is color coded and clouds are shown in shades of gray (Hayden et al., 1996). Routinely, three DPIs are generated by NESDIS every hour depicting atmospheric stability, atmospheric water vapor, and cloud heights. Each FOV thus contains information from the GOES sounder with the accuracy discussed in the previous sections, but the time sequences of the GOES DPI make the information regarding changes in space and time much more evident.

An example of the atmospheric stability DPI is shown in Figure 1. On 8 July 1997 a sequence of the GOES LI DPI, at two hour intervals over the western plains, shows strong de-stabilization in Kansas and northern Oklahoma during the afternoon (1746 to 2146 UTC) as LI values of -8 to -12 C give way to convective clouds. Severe weather watch boxes from the Storm Prediction Center (SPC) covered Missouri and Arkansas as well as eastern Colorado (as the mesoscale vorticity center drifted southward across Missouri into Arkansas with a surface outflow ahead of it). However, storms also formed in west central Kansas by 2146 UTC and continued to develop across the state with numerous reports of hail. Although the Arkansas and eastern Colorado activity was well anticipated at the SPC, central Kansas convection did not appear within a watch area. The strong and focused de-stabilization as noted in the GOES LI DPI sequence over Kansas and northern Oklahoma presented good supporting evidence for development of strong storms in that region. As these examples demonstrate, the sounder is often providing new information to the nowcasting arena.

4. ETA MODEL IMPACT

The positive Eta test results of section II prompted operational use of GOES-8/9 three-layer precipitable water retrievals every three hours beginning October 22, 1997. The initial results have been gratifying. The equitable threat scores and threat biases for the accumulated 24 hour forecast precipitation from the operational Eta model showed improved performance through the last quarter of 1997 (see Figure 2). The threat score improved from about 0.2 to about 0.3. Two verification areas are attached: 48 states, and a western region focusing on the impact of GOES-9. Scores were computed using rain-gauge data from the River Forecast Center network as validation (Menzel et al., 1998).

5. GOES-10 Science Test

A GOES-10 science test occurred mid-March to mid-April. The spacecraft is being operated in a yaw flipped mode to mitigate solar array problems. GOES-10 derived products from the sounder have been found to be comparable to those from GOES-8 and -9. The signal to noise for the GOES-10 sounder is the first to meet specification for all bands (better than 0.5 C viewing 290 K targets including the difficult longwave infrared bands above 13.3 microns). The sounder was operated in a fifteen minute repeat mode over the midwestern United States; these research data sets are being studied for possible improved products and operational scenarios.

6. SUMMARY

The GOES sounder data and products are produced on a higher space and time scale than conventional observations. The overall quality of the GOES sounder measurements and the added information from the products have been verified by comparison to independent observations. Sounder products from both GOES-8 (at 75 W) and GOES-9 (at 135 W) are being used operationally by the National Weather Service.

GOES soundings are available hourly to help assist the NWS produce accurate forecasts/nowcasts of severe weather (such as the Kansas hail situation). GOES-8/9 moisture impact on numerical weather prediction (NWP) is positive. Operational use in the last quarter of 1997 lifted equitable threat scores of 24 hour precipitation forecasts by 0.1. These improvements are expected to increase as direct assimilation of GOES sounder radiances becomes a reality in late 1998.

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. Another site with real-time GOES sounder products supported by the NOAA/NESDIS Forecast Products Development Team is http://orbit7i.nesdis.noaa.gov:8080/goes.html.

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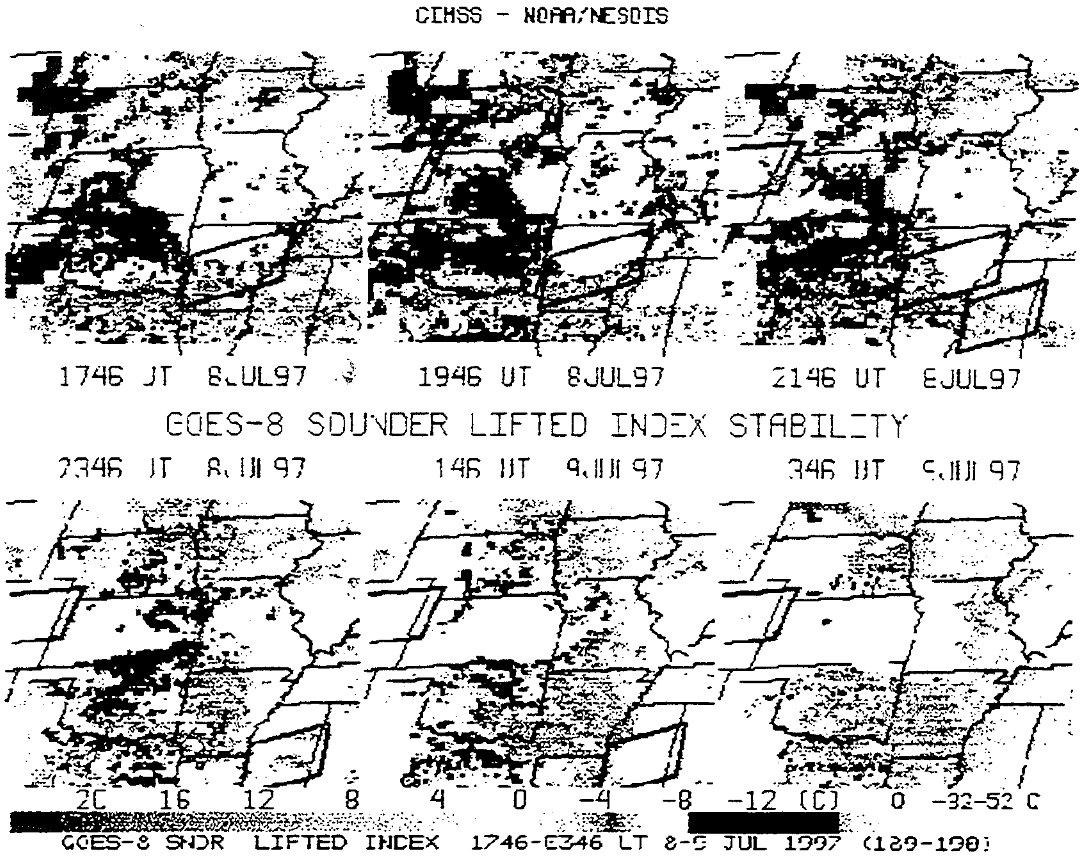
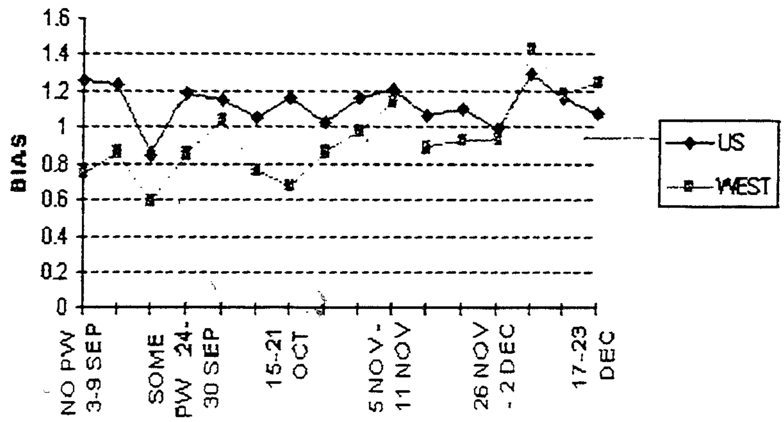
Schmit, T. J., 1996: Sounder bias correction of the east-west gradient. *Technical Proceedings of the Society of Photo-Optical Instrumentation Engineers International Symposium on GOES-8 and Beyond*, August 4-9, 1996, Denver CO, Int. Soc. for Optical Eng., **2812**, 630-637.

Smith, W. L., 1983: The retrieval of atmospheric profiles from VAS geostationary radiance observations. *Jour. Atmos. Sciences.*, **40**, 2025-2035.

Fig 1. Two hourly GOES LI DPI on 8 - 9 July 1997 showing focused strongly unstable conditions over Kansas and northern Oklahoma where severe storms subsequently developed. Severe weather watch boxes issued this day are overlaid.



24HR ETA WEEKLY PRECIP BIAS (VERIFIED AGAINST RFC RAIN DATA, 1-600MM)



24HR ETA WEEKLY EQUITABLE THREAT SCORE (VERIFIED AGAINST RFC RAIN DATA, 1-600MM)

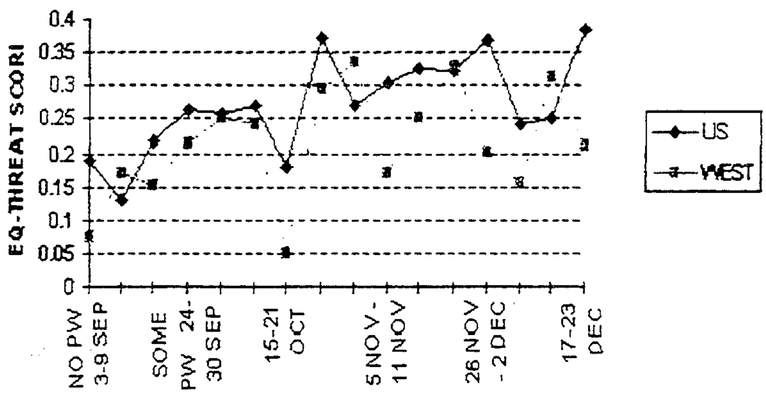


Fig 2. Equitable threat scores (lower panel) and biases (upper panel) for the accumulated 24 forecast of precipitation greater than 1 mm from the operational Eta model for the last four months of 1997. Assimilation of three layers of moisture derived from GOES-8/9 sounders every three hours started *October 22. Scores were computed using rain gauge data from the River Forecast Center network.* Verification for the continental United States as well as the western states is indicated.

CGMS-XXVI EUM-WP-20
Prepared by EUMETSAT
Agenda Item: II.4

IMPACT OF SATELLITE DATA ON THE ECMWF 4D-VAR ANALYSES

The impact of the TOVS radiances and geostationary atmospheric motion winds on NWP analyses and forecasts has been recently re-evaluated using the new 4 dimensional variational assimilation system (4D-Var) in operation at ECMWF since the end of November 1997.

This paper has been provided by ECMWF.

IMPACT OF SATELLITE DATA ON THE ECMWF 4D-VAR ANALYSES.

by

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1. IMPACT OF TOVS RADIANCES AND ATMOSPHERIC MOTION WIND VECTORS

The impact of the TOVS radiances and geostationary atmospheric motion winds on NWP analyses and forecasts has been recently re-evaluated using the new 4 dimensional variational assimilation system (4D-Var) in operation at ECMWF since the end of November 1997. Earlier experiments using the old optimal interpolation assimilation methods had not demonstrated significant benefits of assimilating satellite data over the Northern Hemisphere. The 4D-Var system makes better use of the data as it takes into account the exact time of the observation. In addition, compared with optimal interpolation, one major advantage of 4D-Var is that it can handle observations which are non-linearly related to the analysed quantities. For example it can directly assimilate radiance measurements from satellites.

Two series of Observing System Experiments (OSE's) were run for periods in May 15 to May 31 1997 and November 28 to December 16 1997 using the new 4D-Var system. These OSE experiments systematically removed the following observing systems from the full operational system where all the observations were used (CONTROL):

i) TOVS radiance data from the 2 NOAA satellites removed (NO TOVS).

ii) Geostationary Atmospheric Motion Winds (AMW's) from cloud and water vapour features removed (NO AMW).

iii)The combined removal of both (i) and (ii) (NOSAT).

The results are given in terms of impact on the mean 200hPa forecast wind fields which is an important parameter for aviation forecasts. Figure 1 shows the overall impact of the satellite data averaged over the 35 days in May and Nov/Dec 1997. An increase of 8 hours in predictability is demonstrated for the short to medium range forecasts over the Northern Hemisphere. In the Tropics and Southern Hemisphere an increase of over a day in predictability is achieved when the satellite data are used. More details of earlier experiments, based on 3-dimensional variational assimilation, can be found in Kelly (1997).

AMWs have most value in the Tropics but give a significant improvement in the short range in the Northern Hemisphere. TOVS have a significant impact everywhere especially in the Southern Hemisphere. Through the geostrophic balance in the extra-tropics the TOVS and AMWs can complement each other (e.g. small impact of AMWs in the southern hemisphere) but in the Tropics both datasets are important for defining the initial atmospheric state which is clearly shown in Figure 1. It was also interesting to note that AMWs seem to contribute more to the forecast improvement when used with TOVS data.

For these experiments the use of the TOVS radiances and AMWs over land in the Northern Hemisphere is very restricted. Experiments are now underway to use more of the satellite data over land to increase the impact of satellite data over the Northern Hemisphere. This has become increasingly important to mitigate the loss of upper air measurements from the radiosonde network in recent years.

2. IMPACT OF SCATTEROMETER WINDS

Wind vectors over the sea surface measured by the ERS-1/2 satellites operated by the European Space Agency have been assimilated in the ECMWF analyses since the introduction of 3D-Var at the end of January 1996. Small positive impacts on the short-range surface wind forecasts were seen in the extra-tropics when scatterometer data were included in the assimilation.

One of the more striking impacts with scatterometer data in 4D-Var has been on the analysis and forecasting of tropical cyclones (TCs) despite the narrow swath of the ERS scatterometers. Improvements in both the forecast TC strength and position are seen as shown in Figure 2 for Hurricane Luis in September 1995. The optimal interpolation assimilation in use at the time (without scatterometer data) did not forecast any tropical cyclone (Fig. 2 top panel). The 4D-Var system even without scatterometer data was able to forecast a weak TC (middle panel) but when ERS-1 scatterometer winds were also assimilated the strength of the forecast TC was significantly increased (lower panel) and was much closer to the analysed strength. The assimilation of scatterometer data has also improved the accuracy of the analysed and forecast positions of TCs out to 5 days.

3. IMPACT OF SSM/I TOTAL COLUMN WATER VAPOUR

The DMSP satellite series include a microwave imager as part of its payload referred to as the Special Sensor Microwave Imager (SSM/I). The radiances measured by SSM/I at 4 frequencies and 2 orthogonal polarisations allow several variables to be retrieved. For example the lD-Var retrievals processed operationally at ECMWF provide simultaneous retrievals over the ocean of total column water vapour, surface wind speed, and cloud liquid water path (Phalippou, 1996).

Using the 4D-Var assimilation system the lD-Var retrieved total column water vapour is assimilated to modify the model's first guess specific humidity fields below 300hPa. The mean impact on the analyses over a 18 day period in December 1997 is shown in Figure 3. The assimilation of the SSM/I product moistens the tropical belt by 2-3% when compared with the same model which has not assimilated the SSM/I data. Some benefits were also seen in the forecast performance of the extratropical fields when SSM/I data are assimilated. More details are available in Gerard and Saunders (1998)

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Phalippou, L. 1996 Variational retrieval of humidity profile, windspeed and cloud liquid water path with the SSM/I: Potential for numerical weather prediction. Q.J. Roy. Meteorol. Soc. 122, pp. 327-356

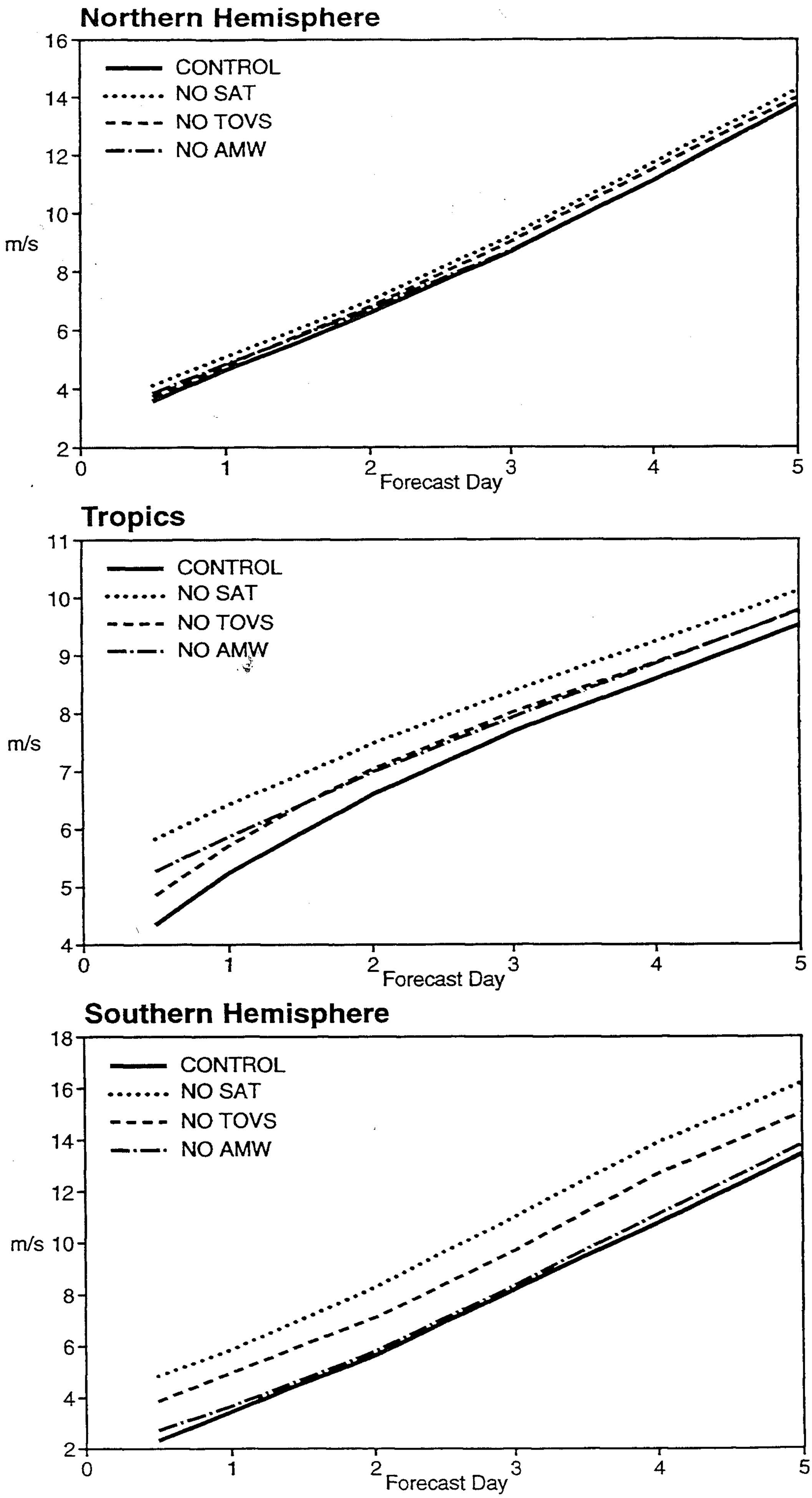


Figure 1. 200hPa vector wind root mean square error for ECMWF forecasts using 4DVAR out to 5 days averaged over 38 forecasts for May and Nov/Dec 1997.

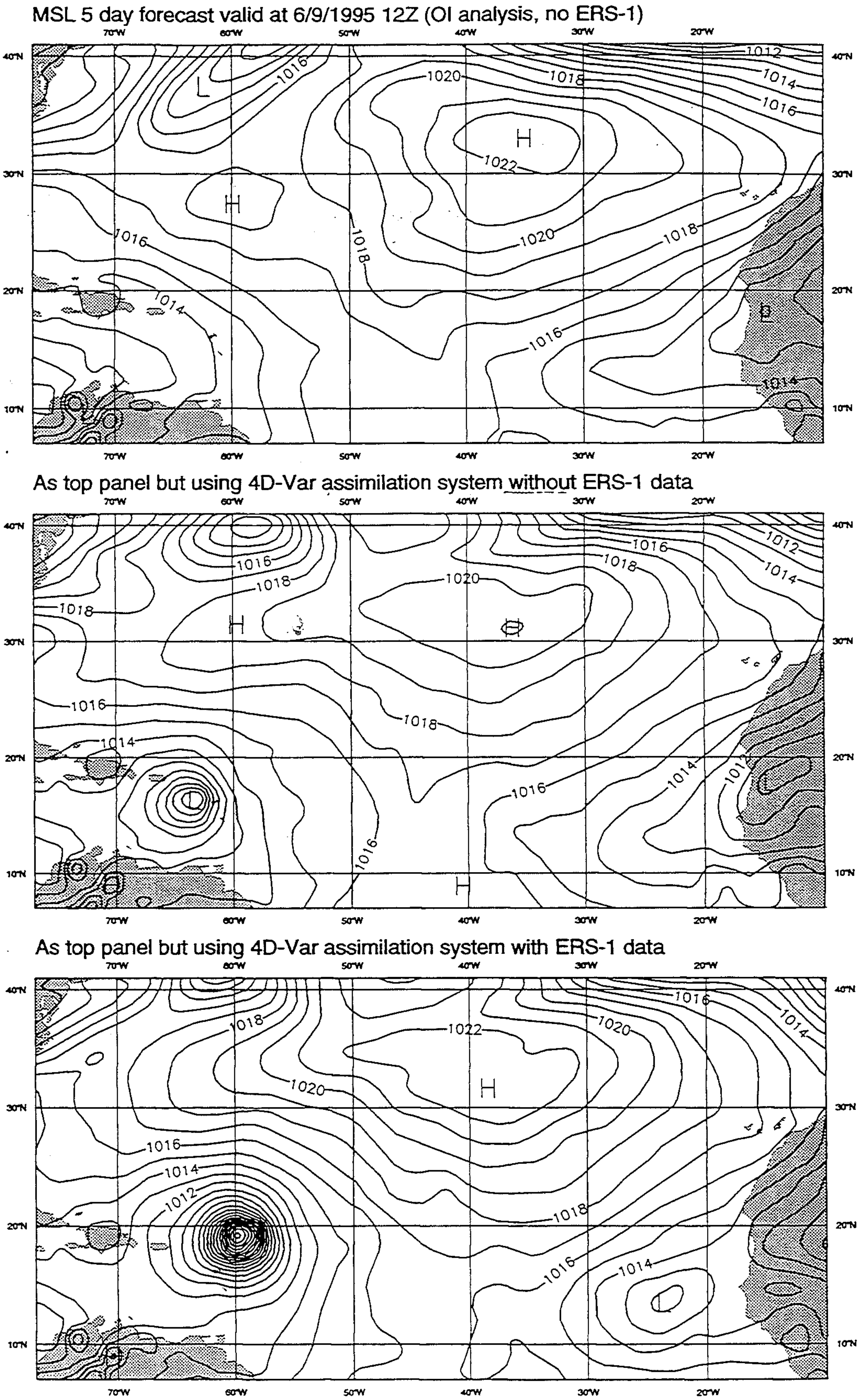
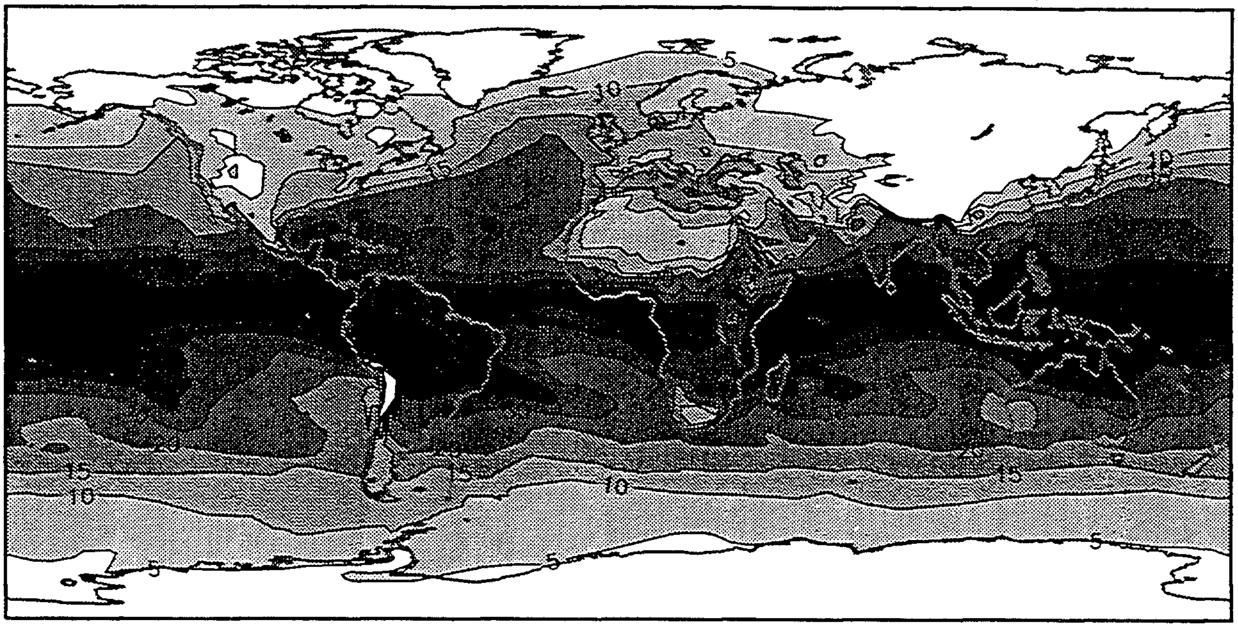


Figure 2. Five day forecasts of mean sea level pressure for the optimal interpolation assimilation with no ERS-1 winds (top panel), with 4D-Var but no ERS-1 winds (middle panel) and with 4D-Var and ERS-1 winds (lower panel). The forecast tropical cyclone is Hurricane Luis.

Analysis TCWV 28Nov-15Dec97 - Exp atea [with SSM/I TCWV] - Global Mean: 24.7043 kg/m2



Analysis TCWV 28 Nov - 15 Dec 97 - [Exp - Ctr] - Global Mean: 0.417108 kg/m2

-20 – -5 -5 – -3 -3 – -1 -1 – 1 1 – 3 3 – 5 5 – 20

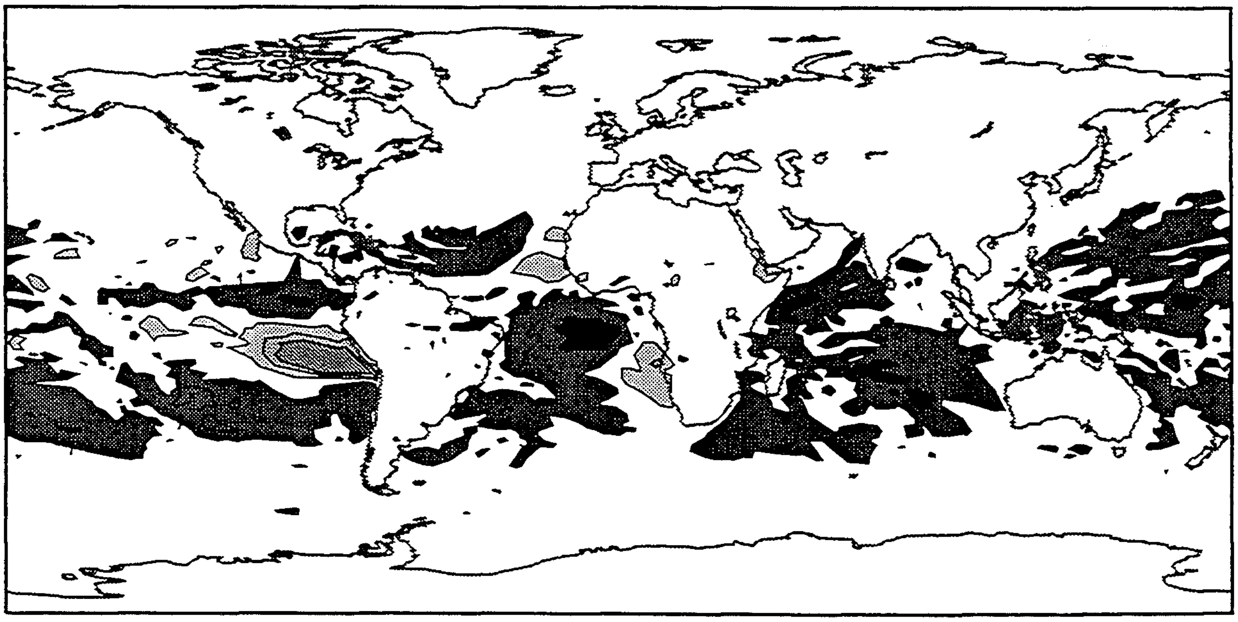


Figure 3. Analysed total column water vapour averaged over 18 days in December 1997 with SSM/I data assimilated (upper panel) and mean difference between analyses with and without SSM/I data (lower panel). Units are kg/sq.m.

EUMETSAT EXPERIENCE IN TRANSFERRING INTO OPERATION THE RESULTS OF RESEARCH ON PRODUCT DEVELOPMENT

Following an intense ad-hoc discussion on the transfer of product research and development into operations at satellite operations centres, CGMS XXV tasked each satellite operator to report on their relevant experience. This paper briefly presents the EUMETSAT experience.

EUMETSAT EXPERIENCE IN TRANSFERRING INTO OPERATION THE RESULTS OF RESEARCH ON PRODUCT DEVELOPMENT

1 INTRODUCTION

Following an intense ad-hoc discussion on the transfer of product research and development into operations at satellite operations centres, CGMS XXV tasked each satellite operator to report on their relevant experience.

It is widely recognised that advanced meteorological products derived from meteorological satellites require continuous development in order to be competitive with other information available to the users. This situation is brought about by the fact that the important user community at weather services and forecasting centres perseveres in research and development in order to improve their services. A notable example, underlining the need of continuous development, are the winds derived from successive satellite images (satellite tracked winds): while studies in the early eighties at the European Centre for Medium Range Weather Forecasts had shown a positive impact of satellite tracked winds on forecasts, the situation reverted in the mid-eighties. This was due to the rapid progress in NWP data assimilation while the concurrent development on the satellite wind product was idle. Work on improving the satellite winds then started again in the mid-eighties and the product has reached and retained a good quality since then.

2 LIFE CYCLE OF PRODUCTS

The life cycle of a product goes through various well-defined steps during its development. The steps can be summarised as follows:

1. A physical concept is developed that relates satellite observed quantities (e.g. radiances) to a quantity a user wants.
2. The physical concept is formulated in a rigorous mathematical framework, which is called an algorithm.
3. The mathematical model is realised as a software code (it should be noted that different realisations of the mathematical model are possible).
4. The computerised algorithm is tested. Flaws or errors are corrected by reconsidering the previous steps.
5. The algorithm is integrated into the operational ground segment environment.
6. The product is tested by people not involved in the development ("β-Testing")
7. The product is tested in the operational environment for which it is designed.
8. The product fulfils the user needs and is declared operational.

2.1 Realisation of the Testing

Typically scientific research and development only includes the steps 1 – 4, because steps 5 and 7 cannot usually be performed by the developers themselves. However, steps 5, 6 and 7 are indispensable in order to get the final step 8.
The integration of new scientific software (algorithms) into the operational environment is a

pre-requisite for further testing (β-testing), since the new product can be tested quasi-operationally in a test chain.

Concerning step 7 one has to rely on external testing, because the external, operational testing cannot be performed at the satellite operations centre where the product is developed and operationally derived. Therefore it is important to arrange for a close co-operation between the user community and the product developers. For instance the ultimate test of satellite winds is their performance and impact in numerical weather prediction models. Therefore, a close co-operation between NWP centres and satellite wind producers is a pre-requisite for a successful and timely completion of a life cycle of products for NWP.

It is emphasised that the scientific development of an algorithm is only one ingredient to the complete development. The integration of the scientific software into the operational environment is a distinctly different task, which often requires changes in the operational software chain. The initial new development of an applications ground segment is a formidable engineering task which needs at least as much attention as the scientific algorithm development.

3 EUMETSAT EXPERIENCE

The experience of EUMETSAT during its first three years of operations and the previous experience at the Meteosat operations centre at ESOC clearly support the views laid out in the previous section. The successful development of satellite products (notably winds) has been and is based on:

- excellent capabilities for in-house development of products
- an operational, parallel chain for β–testing of products
- a capable operations team that readily integrates new algorithms into the operational environment
- strong links with NWP centres (notably with ECMWF) providing essential feedback and guidance which helps to plan and perform the product development according to user needs
- immediate reaction to changing user needs and subsequent concerted activities
- a thorough project plan for the product development and completion

Last but not least, it is also important to maintain the link with the research community that always has the potential to provide novel ideas, which are worthwhile to be pursued in an operational environment. Concerning satellite winds, the International Winds Workshop has established itself as a good forum that brings together researchers, developers and user community.

4 CONCLUDING REMARK

The need for development continues to exist throughout the whole utilisation time of a satellite product. That is, ideally speaking the eight steps outlined above should be cycled through in a continuous manner. The feedback provided from the user during the testing and/or operational use of a product triggers the questioning and revision of steps 1 through 4. Thus product development should remain a continuous activity which is driven by the satisfaction of the user with a product and the innovation of the product developers.

CGMS-XXVI WP- 17
Prepared by Japan
Agenda Item : III/4

Satellite Wind Products by MTSAT

Summary and Purpose of Document

The purpose of this document is to present the current status of development of satellite wind products by MTSAT and the preliminary results of validation.

No action required

CGMS-XXVI WP-17
Prepared by Japan
Agenda Item : III/4

Satellite Wind Products by MTSAT

In regard to the optimum time interval between successive images for the computation of cloud motion winds (CMWs), it was shown that a reduction of time interval is very effective in order to increase horizontal density of CMWs. Hamada (1983) showed that the number of CMWs obtained at 15-minute intervals is increased in comparison with that at 30-minute intervals. Shenk (1991) showed that the percent of available tracers for high clouds and low clouds over water is increased from about 45 % to about 60 % and from about 5 % to about 30 %, respectively, due to the reduction of the time interval from 30 minutes to 15 minutes. Uchida et al. (1991) obtained low level CMWs with higher horizontal density by using 7.5-minute and 15-minute interval images than 30-minute interval images in the vicinity of typhoon.

Based on the studies mentioned above, MSC has a plan to produce CMWs and Water Vapor Motion Winds (WVMWs) using image data at 15-minute intervals when MTSAT will be in operation.

A tentative schedule of MTSAT image observations for wind extraction is shown in Table 1. Two successive observations of the Northern Hemisphere at 15-minute intervals are followed by a full disk observation and two successive observations of the Southern Hemisphere at 15-minute intervals. Calculation of wind vectors is carried out in the Northern Hemisphere and in the Southern Hemisphere respectively using three consecutive images at 15-minute intervals including the full disk image.

In order to produce wind vectors, MSC is developing a software further to produce wind vectors using 15-minute interval images. In addition MSC started to investigate the characteristics and the issues of wind vectors at 15-minute intervals in comparison with those at 30-minute intervals.

We made a comparison between the result at 15-minute intervals and that at 30-minute intervals with a focus on High-level CMWs (HCMWs) and WVMWs in the following one case observed around 04 UTC (Observations at 15- minute intervals) October 25, 1996.
---- Cloud band associated with a frontal zone in the vicinity of Japan.

Observation times of three images for extracting satellite winds are as follows,

- image (A) : 03:28 UTC, image (B) : 03:43 UTC and image (C) : 03:58 UTC on October 25, 1996.

We hereafter call wind vectors at 15-minute intervals as short-time wind vectors to distinguish them from wind vectors at 30-minute intervals.

We selected 300 targets in the region enclosed by 30N - 50N latitude and 110E - 140E longitude lines on the image (A). Then we extracted satellite winds by tracking targets between image (A) and (B) for short-time wind vectors and between image (A) and (C) for wind vectors. All procedures of satellite wind extraction were carried out automatically by using the current operational Cloud Motion Wind Estimation System at MSC.

Table 2 shows the number of HCMWs and WVMWs extracted at 15-minute intervals and 30-minute intervals. The number of satellite winds calculated at 15-minute intervals is increased about 20 % more than that at 30-minute intervals. This result agrees with the Shenk's(1991) result mentioned before.

Comparing the short-time wind vectors with the wind vectors on the image (A), we found out that the number of short-time wind vectors was increased in the area where the contrast difference between the target and the surrounding was small (the image is not shown here). Thus it is inferred that short-time imaging makes it easier to trace a target with a small contrast difference between the target and the surrounding.

Increase in HCMWs and WVMWs is expected by using images obtained at 15-minute intervals in place of current 30-minute intervals as described in the example above. A continual investigation will hereafter be made on accuracy of short-time wind vectors.

REFERENCES

Hamada, T. (1983) : On the optimal time-interval of satellite image acquisition for operational cloud motion wind derivation, Meteorological Satellite Center Technical Note No.7, pp. 79 - 87.

Shenk, W. E. (1991): Suggestions for improving the derivation of winds from geosynchronous satellite. Operational Satellites: Sentinels for the monitoring of climate and global change. Global and Planetary Change, 4, 165 - 171.

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Uchida, H., T. Ohshima, T. Hamada and S. Osano (1991) : Low-Level Cloud Motion Wind Field Estimated from GMS Short Interval Images in Typhoon Vicinity, Geoph. Mag., 44, No.1, pp. 37 - 50.

Table 1 Schedule of MTSAT Imager Observations (draft)

UTC	0 – 30 (min)		30 – 60 (min)
	01	28	32 – 59
00	Southern	Southern	Full Disk - 01
01			32 – 59: Full Disk - 02
~	~		
05	Northern	Northern	Full Disk - 06
06	Southern	Southern	Full Disk - 07
~	~		
23	Northern	Northern	Full Disk - 00

Remarks:

Full DISK -nn	: Full Disk observation for nn UTC
Northern	: Northern hemisphere observation for wind extraction
Southern	: Southern hemisphere observation for wind extraction

Table 2 The number of satellite winds obtained at 15-minute intervals and at 30-minute intervals.

	15-minute intervals	30-minute intervals	The number of targets
HCMWs	169	104	300
WVMWs	239	177	300

DERIVATIONS OF OPERATIONAL SATELLITE PRODUCTS IN IMD

An overview of operational INSAT and TOVS products is presented in this working paper. In addition to winds, OLR, QPE and SST are inferred from geostationary data.

I. DERIVATION OF OPERATIONAL SATELLITE PRODUCTS IN IMD

1. Earth imagery in visible and infrared channels from INSAT at INSAT Meteorological Data Processing System (IMDPS), New Delhi.

2. Earth imagery from NOAA satellite at New Delhi and Chennai (Madras).

3. Derivation of:
   - A. Cloud Motion Vectors at 00, 06, 12 UTC from INSAT.
   - B. Outgoing Long Wave Radiation (OLR) for IR pass and daily/monthly means from INSAT.
   - C. Quantitative Precipitation Estimates (QPE) once a day and monthly mean from INSAT.
   - D. Sea Surface Temperatures from INSAT as well as from NOAA (MCSST).
   - E. Moisture profiles from NOAA.
   - F. Temperature profiles from NOAA.
   - G. Total ozone from NOAA.
   - H. Vegetation index from NOAA (on experimental basis).

II. CLOUD MOTION VECTORS (CMV)

The computation of CMV's involves cloud tracking using pattern matching technique by cross correlation method from a set of 3 half-hourly images.

Pattern matching is being done taking reference window of 16 x 16 pixels and search window of 36 x 36 pixels. The sizes of the windows can be modified.

The height to the CMV's are assigned using the temperature of the IR image after correcting to the pressure levels from the available vertical profile of radiosonde, TOVS or climatology.

Based on the heights, the CMV's are grouped in three levels as low, medium and high.

<u>Following quality checks are applied:</u>

1. Absolute Threshold Test
2. Speed Threshold Test
3. Direction Stability Test
4. Gradient Test
5. Forecast Field Test
6. Climatology Test
7. Man-Machine Interactive Editing

In IMD, the CMV's are derived thrice daily at 00, 06 and 12 UTC over an area of 40 degrees from the sub-satellite point and are disseminated on GTS.

Limitations in derivation of CMV's:

1. The cloud tracers may not be passive tracers.
2. Clouds can be thin or sub-pixel sized with low emissivity, resulting in lower height assignment.
3. Tracers in multi-layered clouds give a mean-layered CMV not valid for any single layer.
4. Tracers in strong vertical wind shear result in wind speed with negative bias.
5. Further mis-registration in triplet frames and inaccuracies in navigation introduce additional error in CMV.

It is generally observed that:

1. There are no CMV's from area of disturbed weather, as the clouds are mainly multi-layered in such scenes.
2. Best agreement is generally found for high levels.
3. Wind speed is generally over-estimated for all levels.
4. Wind direction is poor especially for low and middle levels.
5. CMV's derived from IR images show a zonal bias, while CMV's from visible images are better. This is due to relatively poorer resolution in IR imagery.

III. QUANTITATIVE PRECIPITATION ESTIMATION (QPE)

The QPE is computed using 8 IR images of a day over an area of 40 deg. from the sub-satellite point at 2.5 x 2.5 deg lat/long box using Arkin's technique.

The fractional area covered by clouds colder than threshold temperature (235 deg K) in a given area is used for estimating the Arial average precipitation.

QPE is computed using the formula:

$$QPE = K \times Fc \times N$$

Where	K	is the Arkin's constant, 71,2 mm/day
	Fc	is the fractional cloud cover
	N	is. the number of days

This technique has limitation of minimum grid size 2.5 x 2.5 deg. and minimum time of 24 hour duration.

These estimates are in error specially in areas dominated by orography.

In plain areas and agreement of 75-80% is seen with the ground truth, whereas in hilly regions it is underestimated.

IV. SEA SURFACE TEMPERATURE (SST)

A technique called Mean Estimate Histogram (MEH) is used to compute clear sky brightness temperatures from IR data (10.5 μm – 12.5 μm) in 1 x 1 deg. lat/long box.

The atmospheric attenuation correction is determined from the radiative transfer equation using latest sounding data from TOVS or Radiosonde or Climatology Data Base and the correction is applied to the SST.

Following Quality Control Checks on SST are applied:

1. Spatial Consistency Test.
2. Gradient Test.
3. Climatology Test.

The SST's are being derived over an area of 40 deg. from the sub-satellite point for each IR imagery. Daily/monthly means are also computed.

The SST are also derived from NOAA-12 and NOAA-14 satellites using multi-channel technique (MCSST).

V. OUTGOING LONGWAVE RADIATION (OLR)

In IMD, OLR is computed using IR Data of INSAT over an area of 40 deg. from sub-satellite point in a grid box of 2.5 x 2.5 deg lat/long.

It is computed for every 3-hourly image. Mean daily and monthly OLR is also computed.

OLR is obtained from Stefan Boltzmann Law.

$$OLR = \sigma T_f^4$$

Where σ is the Stefan Boltzmann constant

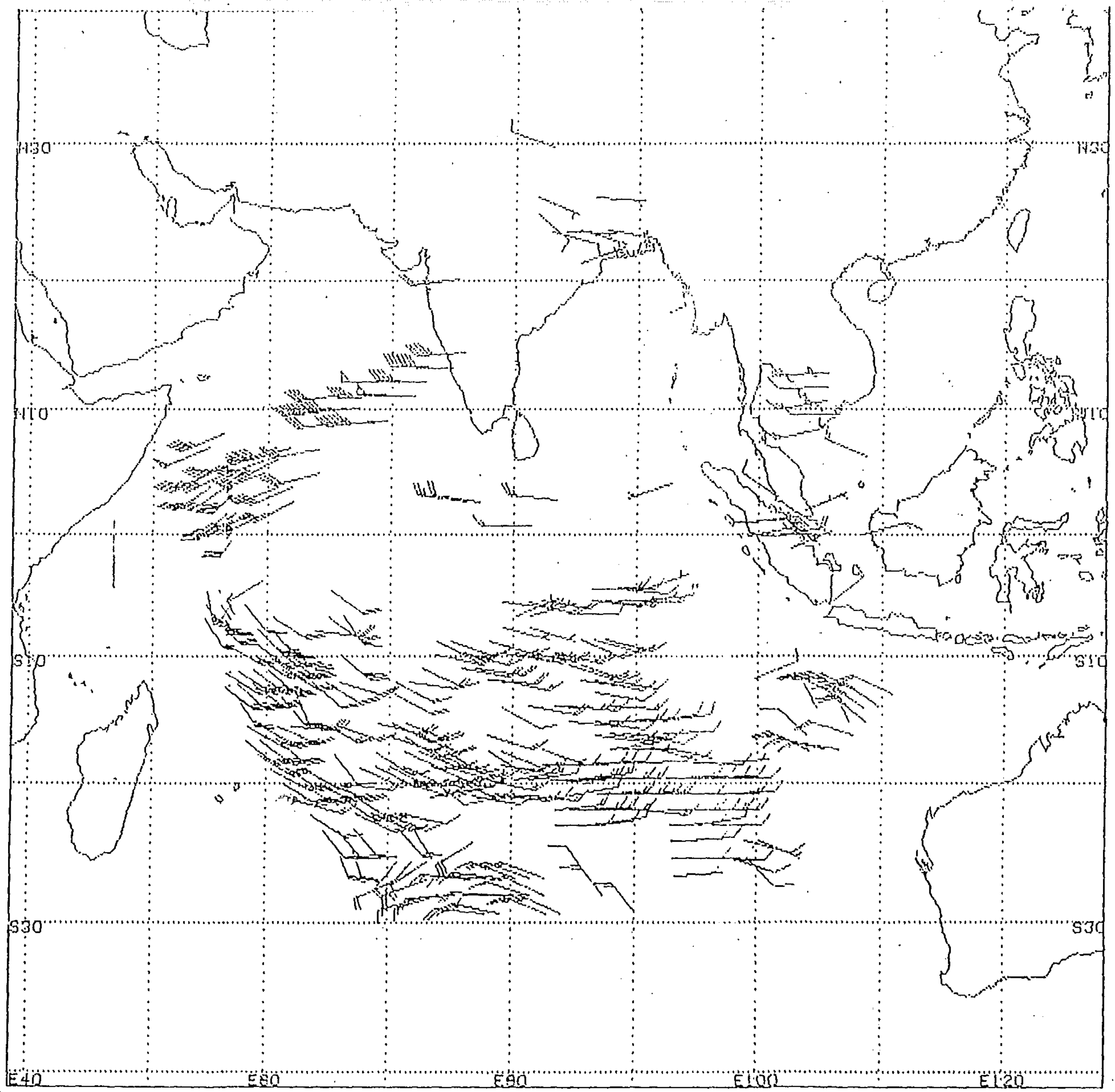
T_f is the flux temperature

$$T_f = T_R\,(a + b.T_R)$$

Where T_R is the brightness temperature

a & b are OLR coefficients

$a = 1.1889$ $\quad$ $b = -9.8906 \times 10^{-4}$



INSAT-II METEOROLOGICAL DATA PROCESSING SYSTEM 3-JUL-1998

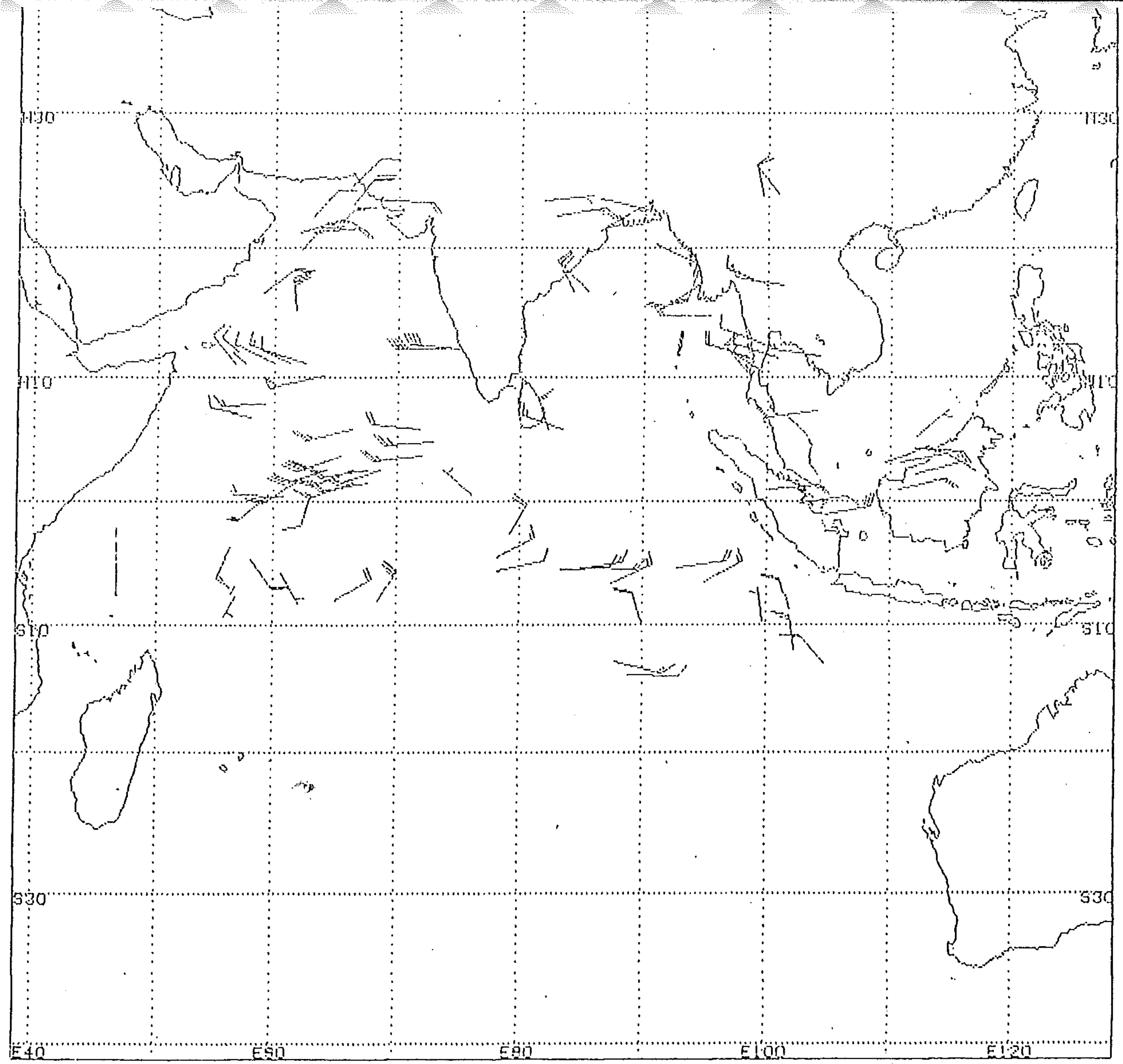
06:07

LOW LEVEL CMV

IMAGE SET : NCMVSEC CENTRE : N00.00/E093.30 SATELLITE : INSATID

FEATURE SET	FEATURE	FEATURE COMMENT
0		
98-07-01 06:00	BASEMAP	BASEMAP
98-07-01 06:00	CMV_LOW	LCMV

98-07-01 06:00 CMV_HIGH HCMV



INSAT-II METEOROLOGICAL DATA PROCESSING SYSTEM 3-JUL-1998

06:10

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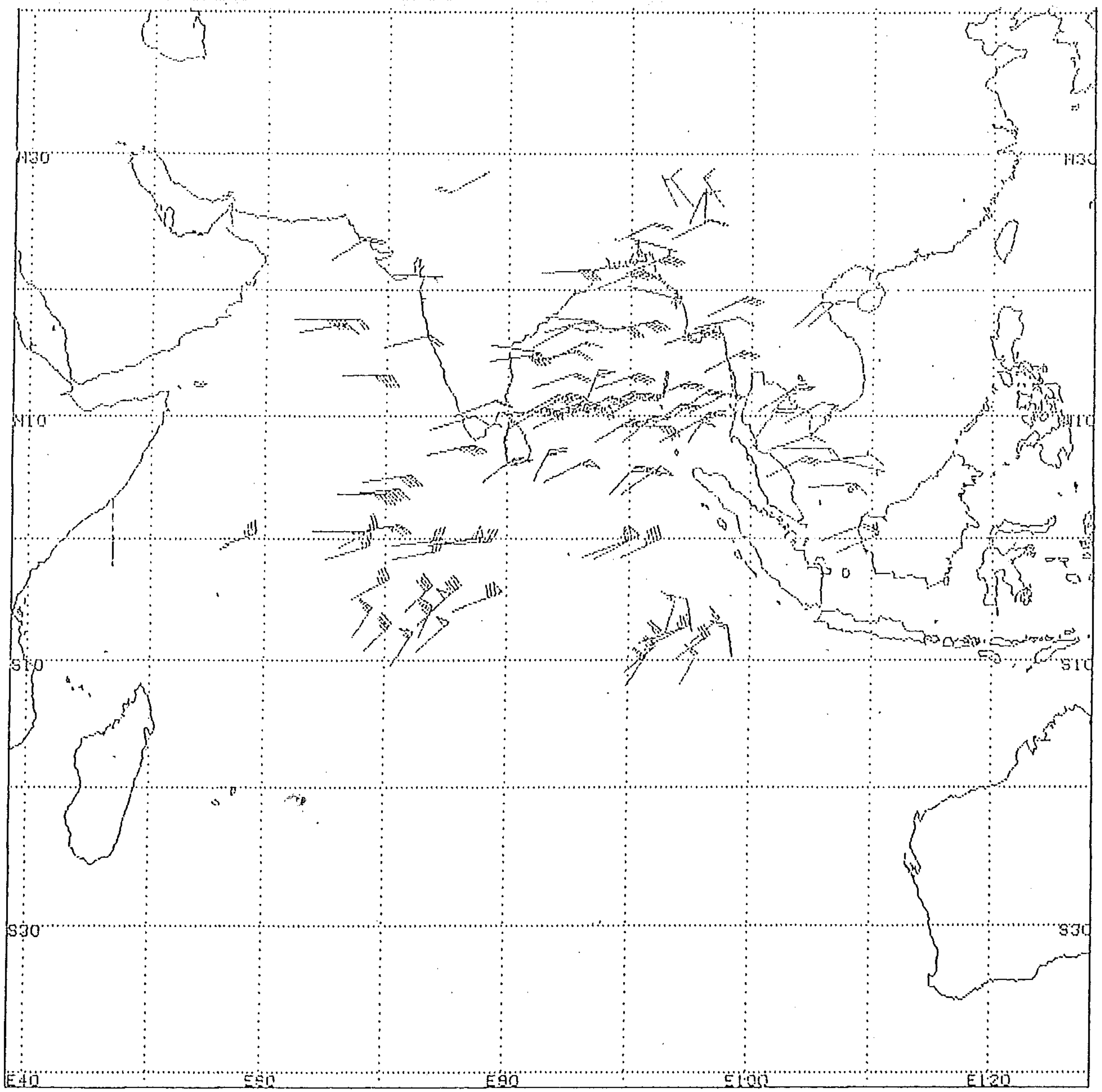

INSAT-II METEOROLOGICAL DATA PROCESSING SYSTEM 3-JUL-1998

06:12

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FEATURE SET FEATURE FEATURE COMMENT

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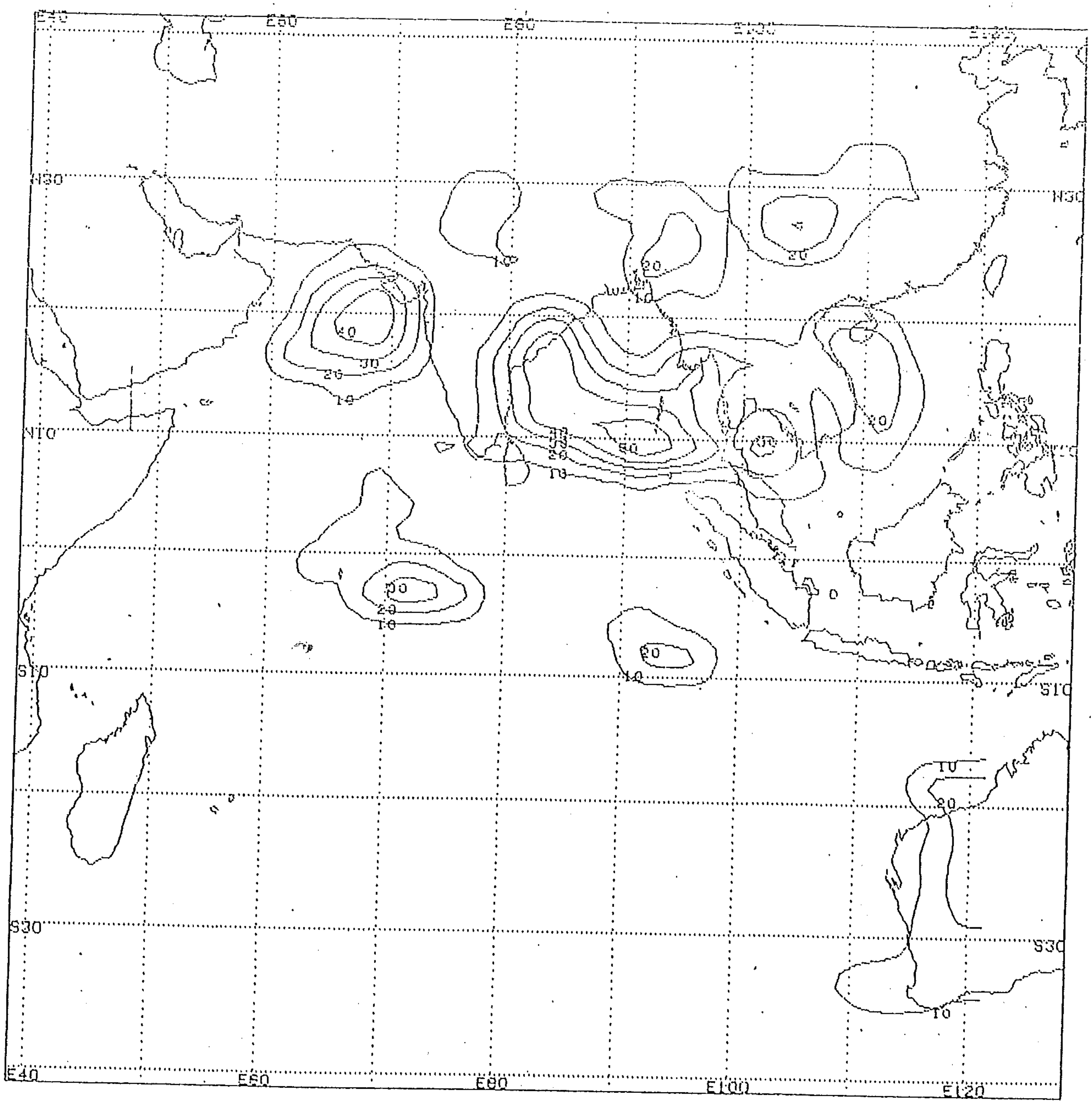

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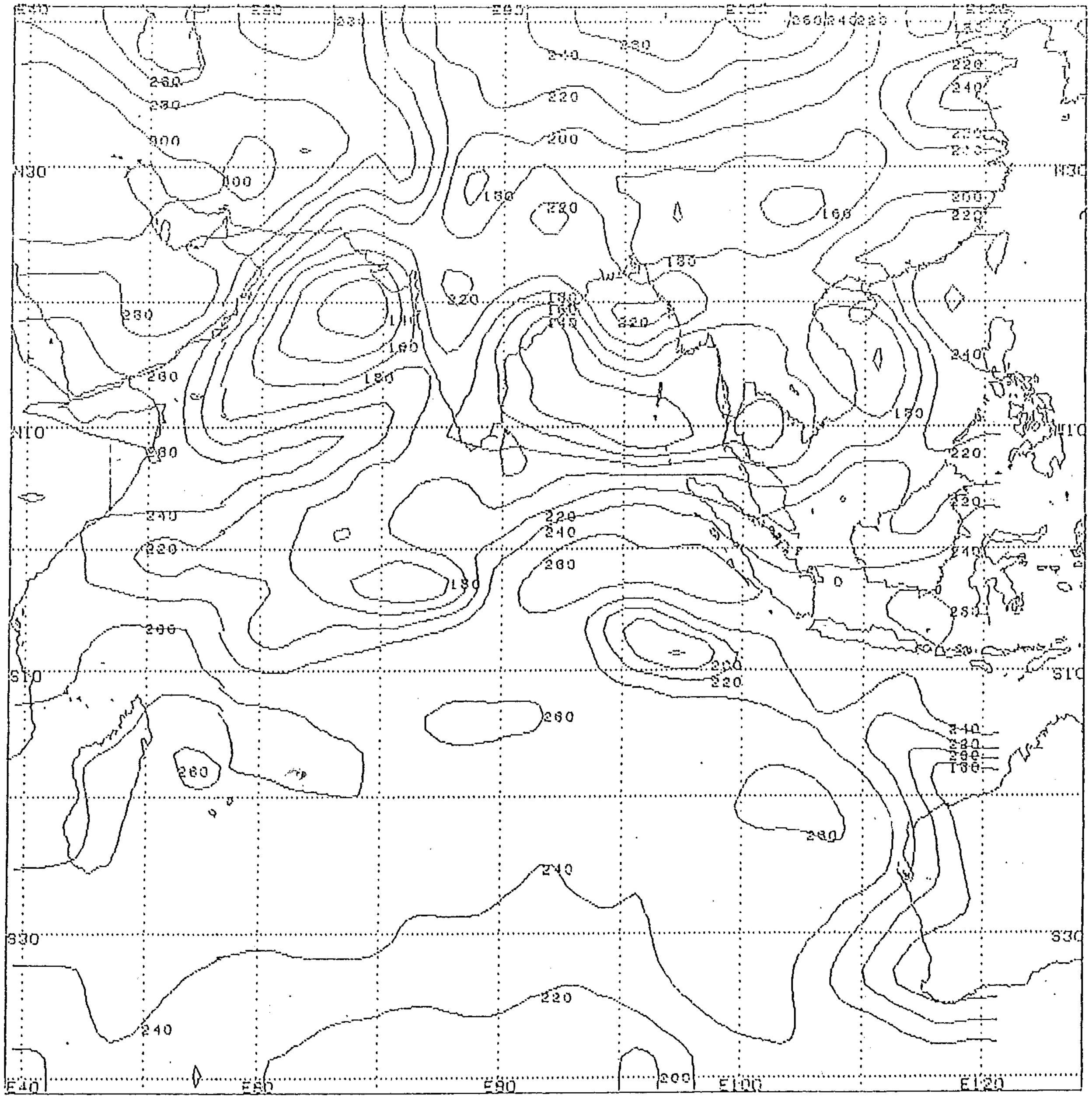

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05:59

ONE DAY MEAN OLR FOR 01-07-98

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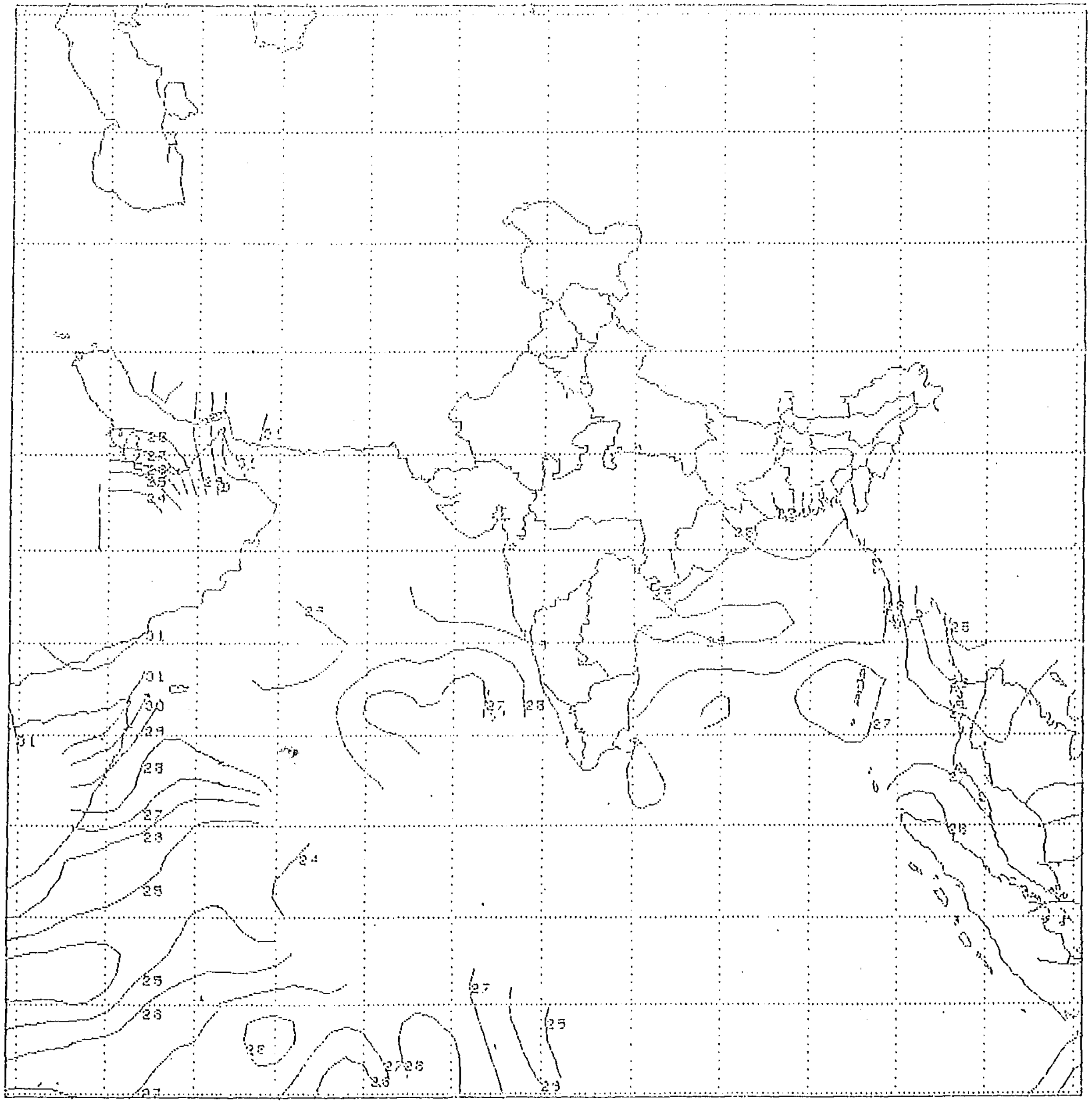

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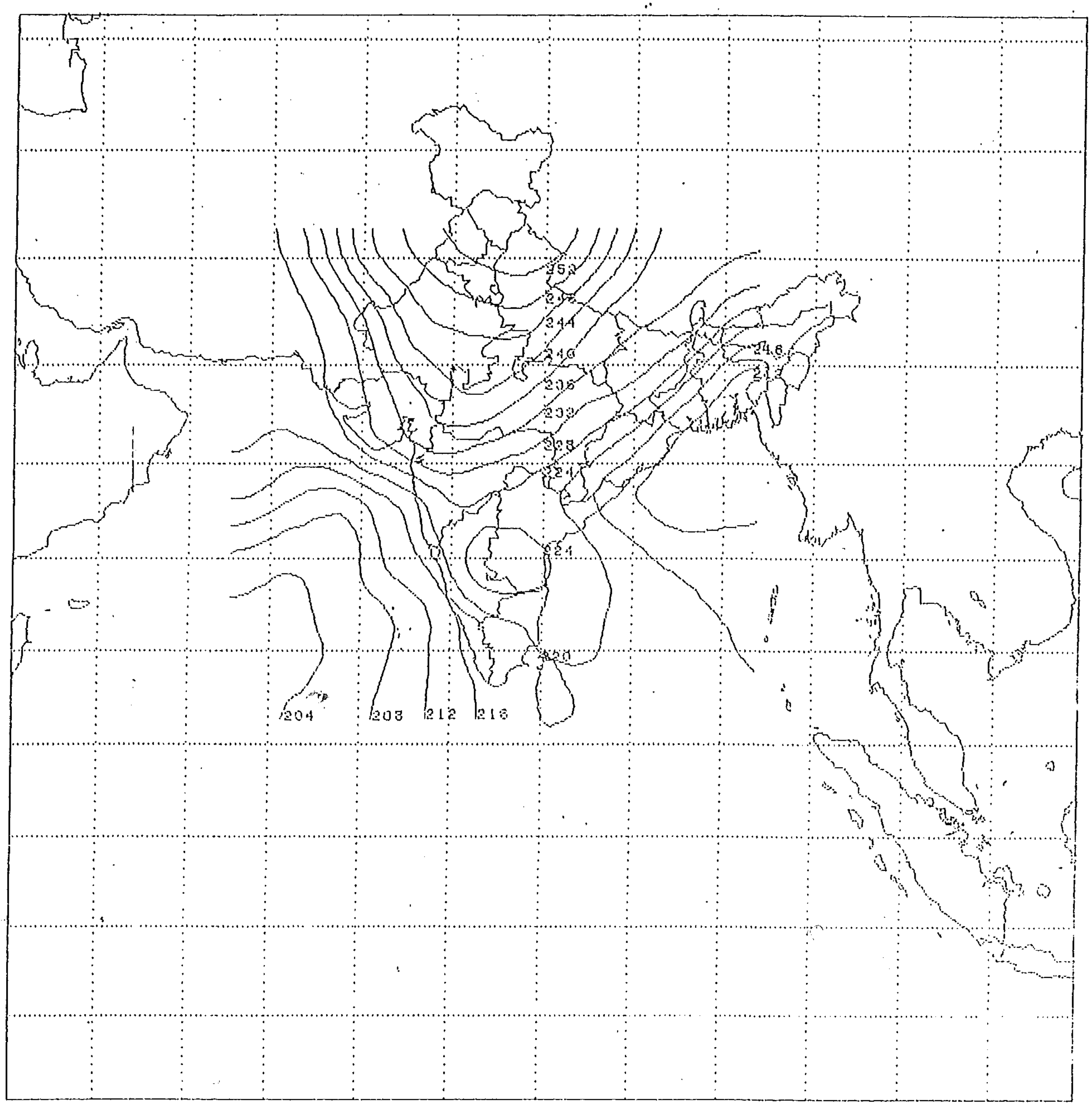

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OZ/Ø11297/144Ø/

IMAGE SET : INSAT1 CCTV MER CENTRE : N15.ØØ/EØ8Ø.ØØ SATELLITE : INSAT1D

REPORT 80 2 4 6 38 12 56
NOAA11 T-Sounding 98-07-02 02:42 2-JUL-98 07:14 PAGE:

Lat.	Long	850	700	500	400	300	250	200	150
35.2	87.3	M	M	6.3	-16.9	-37.5	-43.5	-51.2	-63.9
35.4	90.8	M	M	10.3	-6.5	-23.3	-28.3	-37.8	-52.7
32.5	91.9	M	M	14.7	-2.1	-20.7	-27.8	-38.1	-55.1
31.3	91.8	M	M	5.4	-8.3	-21.1	-28.2	-33.4	-55.2
29.6	91.0	M	M	2.8	-11.8	-24.5	-31.1	-41.2	-56.9
25.5	83.7	15.5	6.6	-4.8	-13.9	-25.4	-34.6	-46.4	-64.2
23.5	83.8	18.5	8.7	-2.4	-10.6	-21.5	-31.1	-43.7	-63.0
24.4	92.3	17.3	8.8	-3.0	-11.9	-24.0	-33.3	-45.3	-62.2
22.6	88.9	17.3	9.1	-2.4	-11.4	-23.8	-33.3	-45.8	-63.3
23.6	94.7	17.1	8.4	-3.1	-11.8	-23.2	-32.5	-44.6	-62.1
22.3	89.5	17.3	9.2	-2.6	-11.9	-24.3	-34.0	-46.3	-63.8
22.4	94.3	18.2	8.4	-4.3	-13.3	-25.1	-34.4	-48.3	-63.5
19.2	83.7	20.3	12.2	1.8	-5.4	-15.1	-24.0	-36.5	-55.5
21.8	98.2	22.9	11.6	-6.3	-16.7	-30.5	-39.7	-50.7	-63.3
19.7	87.9	18.8	11.8	0.4	-8.2	-20.5	-30.8	-44.0	-62.4
20.9	94.4	16.1	7.3	-5.8	-15.7	-23.6	-38.0	-49.5	-65.3
18.3	90.8	14.7	6.5	-4.8	-13.5	-25.0	-34.0	-45.6	-62.6
19.4	97.7	17.7	8.2	-8.0	-19.2	-34.0	-43.4	-54.4	-66.6
17.0	99.7	16.0	6.7	-9.1	-20.5	-35.4	-45.1	-56.7	-63.9

CGMS-XXVI USA-WP-19
Prepared by: USA
Agenda Item: II.4

1997 REPORT ON NOAA/NESDIS AUTOMATED CLOUD-MOTION AND WATER VAPOR DRIFT VECTORS

Summary and Purpose of this document:

Action Proposed:
None

CGMS-XXVI USA-WP-19
Prepared by: USA
Agenda Item: II.4

IV

1997 Report on NOAA/NESDIS Automated Cloud-Motion and Water Vapor Drift Vectors

1. Introduction

The NESDIS operational GOES-8/9 cloud motion vector (CMV) production increased to every three hours (every other wind set is transmitted over the Global Telecommunications System) with high spatial density in the past year. The ~~quality~~ of the wind product is being reported monthly in accordance with CGMS reporting procedures (Schmetz et al., 1997). Planned improvements in the autoediting process (dual pass) and some recent research results (balance of image resolution and time interval between images for tracking features) are briefly discussed.

2. NESDIS Operational Winds

The NESDIS operational winds inferred from infrared window and water vapor images continue to perform well. The quality of the wind product is being tracked according to CGMS guidelines. Figure 1 presents the summary from the last twelve months.

3. High Density Winds

High density winds derived from tracking cloud and water vapor features in sequences of GOES-8/9 images have been placed onto the Global Telecommunications System since early March. Some initial difficulties in the automated scheduling of image loops caused difficulties in the early GTS transmission; these have been corrected since late May. Past experience, especially in hurricane situations, has indicated the enhanced utility of these wind sets. The number of motion vectors has increased dramatically (now over 10,000 vectors for each winds data set) while maintaining the low density winds performance level at 5 to 6 m/s root mean square vector differences with respect to radiosonde observations. In addition, winds production has been increased to every three hours since late 1997. This plethora of motion vectors is being studied in various forecast models; the best approaches toward assimilation remain under evaluation.

One study was conducted at the Geophysical Fluid Dynamics Laboratory (GFDL). High density, multispectral GOES-8 winds (from three water vapor, the infrared window, and the visible bands) were studied for over 30 cases from five tropical cyclone situations in the summer of 1996. The winds were directly assimilated using optimal interpolation and vertical blending schemes. GOES data reduced the trajectory forecast errors at 72 hours by 20% on average; impressive control runs without the GOES data were improved even more with the GOES winds. More work is planned with the National Centers for Environmental Prediction (NCEP) to achieve optimum utilization of the high density winds.

IV. Wind Enhancements Anticipated in 1998

In 1998, several improvements are expected in the operational winds software. (1) Winds inferred from visible image loops as well as sounder mid-level moisture sensitive bands will be added to operations by summer 1998. (2) This will enable ensemble autoediting, where the combined wind sets from visible, infrared window, three water vapor sensitive bands are intercompared for consistency. The dependency on comparison with a model first guess will be diminished. (3) A dual pass autoeditor will be put in place by summer 1998, that will relax rejection criteria for winds around a feature of interest and use normal procedures elsewhere. This enables better retention of the tighter circulation features associated with tropical cyclones and other severe weather. (4) Water vapor winds will be designated as being determined in clear skies or over clouds; the former are then representative of layer mean motion while the latter are cloud top motion. (5) A quality flag will be attached to the wind vector that indicates strength of agreement with the first guess and level of confidence from the autoeditor; this quality flag is being developed in collaboration with EUMETSAT scientists.

5. Winds Study with Special GOES-10 Data Sets

During the GOES-10 science checkout in April 1998, five minute interval observations were made routinely with the imager. These data sets were used to study the balance of image resolution and time interval between images for tracking features. Motion vectors were derived from GOES -10 full resolution water vapor (8 km resolution), infrared window (4 km resolution), and visible (1 km resolution) images from 8 April 1998 near 23UTC using the CIMSS automated procedures. The GOES-10 oversamples in the east west by a factor of 1.75. Three images spaced at 5, 10, 15, and 30 minute intervals were used, with the shorter intervals nested inside longer loops for best time matching. Results (based on quantity, quality, and comparison with radiosonde observations) indicate that the optimal time elapsed between images for visible low level winds is 5 minutes, for infrared cloud motion winds it is 10 minutes, and for water vapor layer drift in clear skies it is 30 minutes. Operational processing currently uses 30 minute sampling for all bands. Synoptic analysis of the wind fields over the Alabama region shows a much improved depiction of the upper-level jet streak and divergence in the optimized (10-minute loop) IR winds. The short-wave circulation to the northwest of the severe weather outbreak is best described by the clear-sky WV winds at 30 minute intervals. Finally, the 5-minute loop VIS winds clearly show a strong low-level inflow into the developing cells which was not depicted well at 30 minute image frequency (see Figure 2).

These preliminary results indicate that the optimum balance of spatial and temporal resolution is not currently being achieved in the half hourly GOES schedule. Further trade-off studies are planned and schedule adjustments will be investigated.

6. SUMMARY

Operational cloud-drift and water-vapor wind production within NESDIS now occurs every three hours; since March 1998 the winds are generated and distributed at high spatial density. Verification statistics for the past year show that product quality has remained steady, and that winds produced from GOES-8 and GOES-9 show similar error characteristics. The next major operational change will be production of motion vectors from sequences of visible images from the imager as well as mid-tropospheric water vapor channels from the sounder.

7. REFERENCES

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

Schmetz, J., H. P. Roesli, and W. P. Menzel, 1997: Summary of the Third International Winds Workshop. Bull. Amer. Meteor. Soc., 78, 893-896.

Velden, C. S., C. M. Hayden, S. J. Nieman, W. P. Menzel, and S. Wanzong, 1997: Upper-tropospheric winds derived from geostationary satellite water vapor observations. Bull. Amer. Meteor. Soc., 78, 173-195.

Table 1. GOES-10 4 km infrared and 1 km visible winds performance at 5, 10, 15 and 30 minutes compared to radiosonde balloon determinations. Model first guess wind estimates are compared to radiosondes also.

IR	RAOB-SAT (m/s)	RAOB-GUESS (m/s)
30 minutes (144 winds)		
BIAS	-0.81	-0.89
RMS	6.38	5.98
15 minutes (251 winds)		
BIAS	-0.97	-1.37
RMS	6.76	6.05
10 minutes (290 winds)		
BIAS	-0.55	-0.97
RMS	7.11	6.61
5 minutes (396 winds)		
BIAS	-1.74	-1.27
RMS	8.01	7.21

Visible	RAOB-SAT (m/s)	RAOB-GUESS (m/s)
30 minutes (167 winds)		
BIAS	-1.09	-2.11
RMS	5.69	4.74
15 minutes (199 winds)		
BIAS	-1.54	-2.25
RMS	4.55	4.68
10 minutes (298 winds)		
BIAS	-1.19	-2.13
RMS	4.73	4.86
5 minutes (429 winds)		
BIAS	-1.16	-2.08
RMS	5.11	5.32

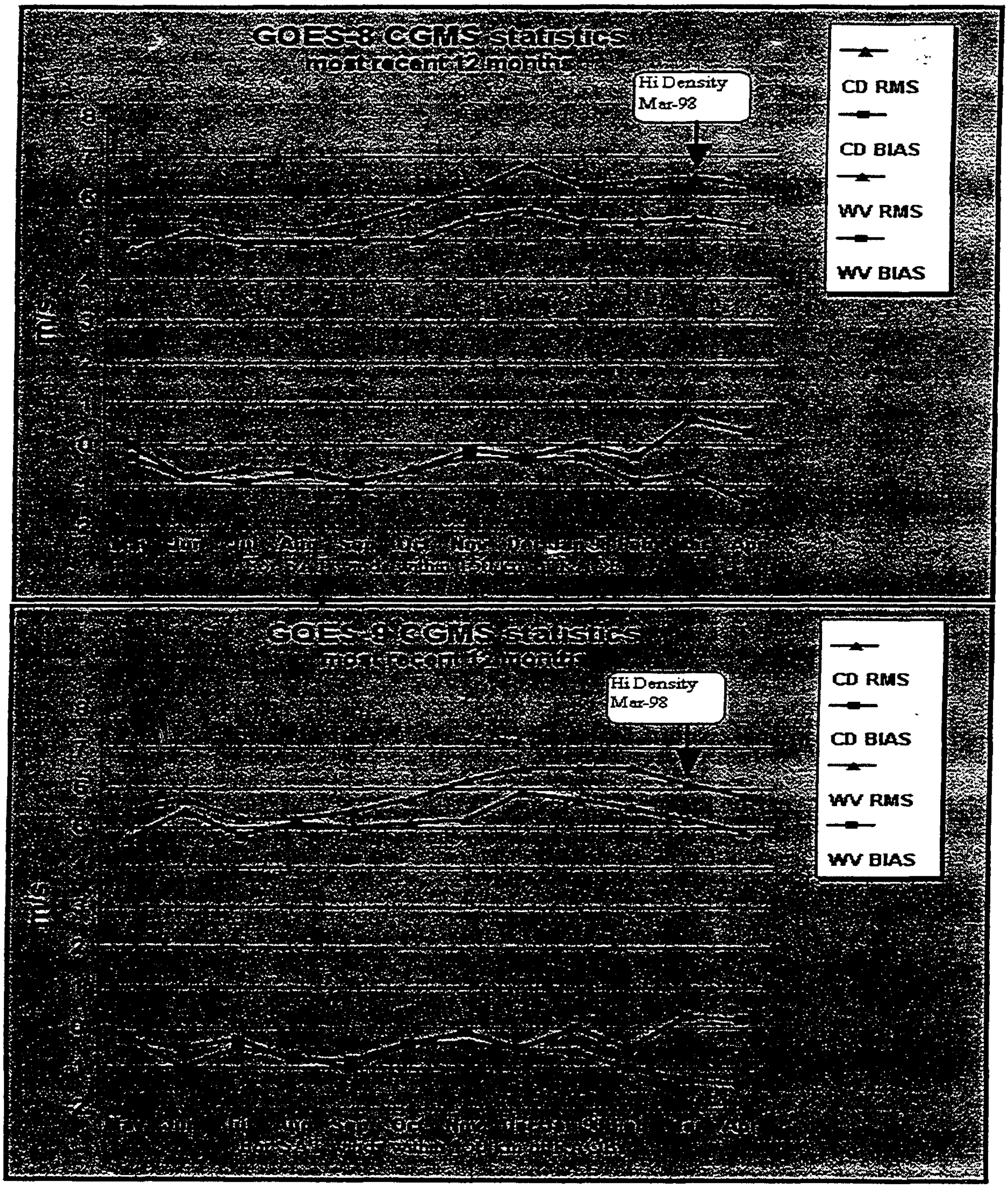

Fig.1. CGMS statistics (bias and root mean square) for GOES-8/9 cloud drift (CD) and water vapor motion (WV) winds for May 1997 through April 1998.

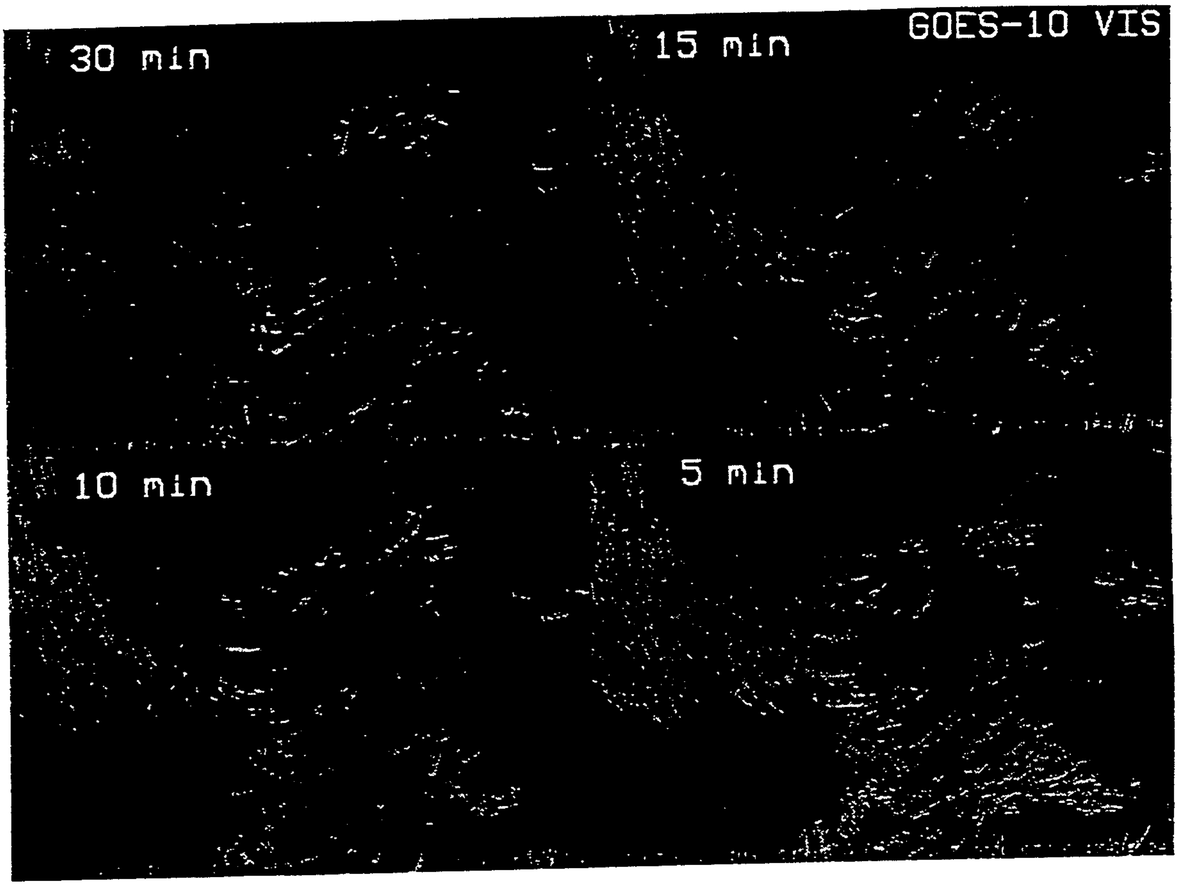

Fig.2. GOES-10 visible winds from 5, 10, 15, and 30 minute loops.

CGMS-XXVI EUM-WP-24
Prepared by EUMETSAT
Agenda Item: III.4

WIND PRODUCTS DEVELOPMENT PLAN OF THE EUMETSAT MPEF

This paper provides information on the development plans for the EUMETSAT METEOSAT Wind Products from the Meteorological Products Extraction Facility (MPEF).

WIND PRODUCTS DEVELOPMENT PLAN OF THE EUMETSAT MPEF

1 GENERAL

The wind products remain the core MPEF products, and significant effort will be spent on improving the service provided. Feedback from the MPEF user community clearly shows a need for improvements. The areas where the current MPEF product can be improved are:

- Low level coverage around developing tropical systems. This is important for hurricane forecasting.
- Low-level height assignment in trade wind inversion areas. In the inversion areas, the Temperature-to-Pressure transformation is multi-valued. This results in low-level IR height assignment problems.
- Medium-level coverage. Although this area presents fundamental meteorological problems, the MPEF wind coverage at medium levels seems to be even poorer than from the old MIEC system.
- High-level height assignment for cloud tracked winds. Significant scope for improvements to the semi-transparency correction.
- Increased resolution in time (<= 3h) for 4-D assimilation. This can only be achieved by generation of fully automated wind products.
- Provision of reliability indicators for speed, direction, pressure and temperature
- Decrease the required amount of detailed manual quality control

The needs of the user community will be addressed partly through improvements to the existing operational wind products (CMW and HRV) and partly through the introduction of new wind products.

2 HRV TRACER SELECTION

The tracer selection and height assignment for HRV will be based on averaging pixel counts over the target area in the pixel-classified image instead of using the segment-based cluster information. This will provide more HRV winds in mixed cloud segments and better coverage in areas with developing systems.

3 HEIGHT ASSIGNMENT IN INVERSION AREAS

The problem of multiple pressure points per given temperature in the trade winds area will be addressed. With the usage of GRIB forecast data on model levels (currently 31), the resolution of the inversion will obviously be better, but the height assignment scheme still requires minor changes to correctly handle the inversion case.

4 IMPROVED SEMI-TRANSPARENCY CORRECTION

Studies indicate that the height assignment of IR and WV winds in many cases fail because of failure to apply a correct semi-transparency correction to the cloud clusters. Several factors can contribute to an improvement in this area:

- The semi-transparency correction can be calculated by using a linear regression on the individual pixels. This eliminates the requirement for background scene identification.
- The quality of the humidity forecast is crucial in determining the radiance curve, and with the rapidly improving humidity fields supplied from the NWP centres an improvement will be expected.
- A posteriori adjustment of the radiance curve to fit the observed background clusters could be investigated.
- The semi-transparency model could be refined to more truly represent semi-transparent clouds.

An improved semi-transparency correction, primarily based on the linear regression technique, is being developed as part of MSG MPEF prototyping, and will be tested for integration into MTP MPEF.

5 AUTOMATIC QUALITY CONTROL

The core issue to be addressed for the MPEF CMW product is the final definition of the AQC processes and parameters. The process is essential to ensure a maximum yield of high-quality winds for all channels and all levels and to ensure the availability of stable reliability indicators for the user community. Optimisation of AQC is also a pre-requisite for providing fully automated products with higher time-resolution. The AQC tuning is based on the continuously growing data set of collocated radiosondes and MPEF satellite winds, as well as on comparisons with ECMWF first-guess fields. The AQC definition process is ongoing with continuous improvements over the next year. From then onwards it is expected, that no major modifications will be performed to the AQC scheme. Extensions to the AQC scheme, e.g. cross-channel AQC between WV and IR, will be applied.

With an optimal AQC the size and coverage of the SATOB encoded product can be increased and meaningful reliability indicators for the BUFR product, including individual reliability indicators for speed, direction and height, can be provided. It will also be investigated whether estimates for the error distribution functions can be produced, which could be used in the NWP data assimilation schemes.

The AQC for the secondary synoptic products (UTH, SST, and CLA) will be improved to make these products fully automatic.

6 MEDIUM-LEVEL IR WINDS

The quality and coverage of the medium level IR winds is relative poor. This is mainly a reflection of the complex physics and dynamics of the mid-level atmosphere, especially over the continents, and no single internal problem causing this has been identified, but the mid-level winds issue will continue to be investigated.

7 WV WINDS FROM CLOUD-FREE AREAS

The tracing of water vapour in cloud-free areas provides a wind product with extensive coverage. This product (WVW) at a resolution of 160 km is now available in test mode, and will be provided as an operational product. The single-level height assignment has been investigated in a separate study, but firm conclusions for the operational products have not yet been made. An assimilation of the winds as average winds over a deep layer is possible in the variational assimilation schemes.

8 HIGH RESOLUTION WV WINDS

MSG prototyping has shown the feasibility of a WV winds product at half-segment size resolution, i.e. 80km, for both cloudy and non-cloudy areas. This product is being prototyped for MTP and will be provided as an operational product in BUFR 16 times per day, if performance constraints allow.

9 INCREASED TIME-FREQUENCY OF WINDS DISTRIBUTION

The MPEF derives winds every 1.5 hours, but only products from the main synoptic times (00Z, 06Z, 12Z and 18Z) are currently disseminated in SATOB after manual quality control. The 1.5 hourly wind products have since March 1997 been disseminated in BUFR on a bilateral basis to ECMWF for testing. The ECMWF experience with this product is so positive, that it is planned to turn this product into an operational product. A further reduction of the wind extraction cycle to 1-hour (MSG baseline) is potentially possible and will be investigated.

10 BETTER GEOGRAPHICAL POSITIONING

Presently the extracted winds are positioned at the segment centres, introducing an inaccuracy of up to half a segment size. A better positioning could be obtained by explicit tracer location in the image, and will be investigated.

11 BETTER DISTRIBUTION ACCURACY

The SATOB dissemination accuracy is only 1 deg, which is inadequate for the high-resolution wind products. The accuracy is improved with the BUFR encoding, which indicates the full accuracy of the wind positioning information.

12 VERIFICATION IMPROVEMENTS

The verification of the CMW product is currently based exclusively on radiosondes and forecast fields. Use of other data (e.g. AIREP/ASDAR/ACARS) for verification is foreseen.

Appendix B:

GENERAL CGMS INFORMATION

CHARTER FOR THE
COORDINATION GROUP FOR METEOROLOGICAL SATELLITES
(CGMS)

PREAMBLE

RECALLING that the Coordination on Geostationary Meteorological Satellites (CGMS) has met annually as an informal body since September 1972 when representatives of the United States (National Oceanic and Atmospheric Administration), the European Space Research Organisation (now the European Space Agency), and Japan (Japan Meteorological Agency) met to consider common interests relating to the design, operation and use of these agencies planned meteorological satellites,

RECALLING that the Union of Soviet Socialist Republics (State Committee for Hydrometeorology), India (India Meteorological Department) and the People's Republic of China (State Meteorological Administration) initiated development of geostationary satellites and joined CGMS in 1973, 1978, and 1986 respectively,

RECOGNIZING that the World Meteorological Organisation (WMO) as a representative of the meteorological satellite data user community has participated in CGMS since 1974,

NOTING that the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT) has, with effect from January 1987, taken over responsibility from ESA for the METEOSAT satellite system and the current Secretariat of CGMS,

CONSIDERING that CGMS has served as an effective forum through which independent agency plans have been informally harmonised to meet common mission objectives and produce certain compatible data products from geostationary meteorological satellites for users around the world,

RECALLING that the USA, the USSR, and the PRC have launched polar-orbiting meteorological satellites, that Europe has initiated plans to launch an operational polar-orbiting mission and that the polar and geostationary meteorological satellite systems together form a basic element of the space based portion of the WMO Global Observing System,

BEING AWARE of the concern expressed by the WMO Executive Council Panel of Experts over the lack of guaranteed continuity in the polar orbit and its recommendation that there should be greater cooperation between operational meteorological satellite operators world-wide, so that a more effective utilisation of these operational systems, through the coordination and standardisation of many services provided, can be assured,

RECOGNISING the importance of operational meteorological satellites for monitoring and detection of climate change,

AND RECOGNISING the need to update the purpose and objectives of CGMS,

AGREE

I. To change the name of CGMS to the Coordination Group for Meteorological Satellites

II. To adopt a Charter, establishing Terms of Reference for CGMS, as follows:

OBJECTIVES

a) 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, telecommunications matters, operations, intercalibration of sensors, processing algorithms, products and their validation, data transmission formats and future data transmission standards.

b) CGMS harmonises to the extent possible meteorological satellite mission parameters such as orbits, sensors, data formats and downlink frequencies.

c) CGMS encourages complementarity, compatibility and possible mutual back-up in the event of system failure through cooperative mission planning, compatible meteorological data products and services and the coordination of space and data related activities, thus complementing the work of other international satellite coordinating mechanisms.

MEMBERSHIP

d) CGMS Membership is open to all operators of meteorological satellites, to prospective operators having a clear commitment to develop and operate such satellites, and to the WMO, because of its unique role as representative of the world meteorological data user community.

e) The status of observer will be open to representatives of international organisations or groups who have declared an intent, supported by detailed system definition studies, to establish a meteorological satellite observing system. Once formal approval of the system is declared, membership of CGMS can be requested by the observer.

Within two years of becoming an observer, observers will report on progress being made towards the feasibility of securing national approval of a system. At that time CGMS Members may review the continued participation by each Observer.

f) The current Membership of CGMS is listed in an annex to this charter.

g) The addition of new Members and Observers will be by consensus of existing CGMS Members.

ORGANISATION

h) CGMS will meet in plenary session annually. Ad hoc Working Groups to consider specific issues in detail might be convened at the request of any Member provided that written notification is received and approved by the Membership at least 1 month in advance and all Members agree. Such Working Groups will report to the next meeting of CGMS.

i) One Member, on a voluntary basis, will serve as the Secretariat of CGMS.

j) Provisional meeting venues, dates and draft agenda for plenary meetings will be distributed by the Secretariat 6 months in advance of the meeting, for approval by the Members. An agreed Agenda will be circulated to each Member 3 months in advance of the meeting.

k) Plenary Meetings of CGMS will be chaired by each of the Members in turn, the Chairman being proposed by the host country or organisation.

l) The Host of any CGMS meeting, assisted by the Secretariat, will be responsible for logistical support required by the meeting. Minutes will be prepared by the Secretariat, which will also serve as the repository ofCGMS records. The Secretariat will also track action items adopted at meetings and provide CGMS Members with a status report on these and any other outstanding actions, four months prior to a meeting and again at the meeting itself.

PROCEDURE

m) The approval of recommendations, findings, plans, reports, minutes of meetings, the establishment of Working Groups will require the consensus of Members. Observers may participate fully in CGMS discussions and have their views included in reports, minutes etc., however, the approval of an observer will not be required to establish consensus.

n) Recommendations, findings, plans and reports will be non-binding on Members or Observers.

o) Once consensus has been reached amongst Members on recommendations, findings, plans and reports, minutes of meetings or other such information from CGMS, or its Working Groups, this information may be made publicly available.

p) Areas of cooperation identified by CGMS will be the subject of agreement between the relevant Members.

COORDINATION

q) The work of CGMS will be coordinated, as appropriate, with the World Meteorological Organisation and its relevant bodies, and with other international satellite coordination mechanisms, in particular the Committee on Earth Observation Satellites (CEOS) and the Earth Observation

International Coordination Working Group (EO-ICWG) and the Space Frequency Coordination Group (SFCG).

Organisations wishing to receive information or advice from the CGMS should contact the Secretariat; which will pass the request on to all Members and coordinate an appropriate response, including documentation or representation by the relevant CGMS Members.

AMENDMENT

r) These Terms of Reference may be amended or modified by consensus of the Members. Proposals for amendments should be in the hands of the Members at least one month prior to a plenary meeting of CGMS.

EFFECTIVE DATE AND DURATION

s) These Terms of Reference will become effective upon adoption by consensus of all CGMS Members and will remain in effect unless or until terminated by the consensus of CGMS Members.

MEMBERSHIP OF CGMS

The current Membership of CGMS is:

EUMETSAT	-	joined 1987, currently CGMS Secretariat
India Meteorological Department	-	joined 1979.
Japan Meteorological Agency	-	founder member, 1972
State Meteorological Administration of the PRC	-	joined 1989
NOAA/NESDIS	-	founder member, 1972
Hydromet Service of the Russian Federation	-	joined 1973

WMO - joined 1973

(The table of Members shows the lead Agency in each case. Delegates are often supported by other Agencies, for example, ESA (with EUMETSAT) and NASDA (with Japan).

ADDRESSES FOR PROCURING ARCHIVE DATA

EUMETSAT

The Meteosat Data Archive Manager
Attention: Mr. R. Francis
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CONTACT LIST FOR OPERATIONAL ENGINEERING MATTERS

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LIST OF ABBREVIATIONS AND ACRONYMS

ACARS	Automated Communications Addressing and Reporting System
ACC	ASAP Coordinating Committee
ADC	Atlantic Data Coverage
AMDAR	Aircraft Meteorological Data Relay
AMS	American Meteorological Society
AMSU	Advanced Microwave Sounding Unit
APT	Automatic Picture Transmission
ARGOS	Data Collection and Location System
ASAP	Automated Shipboard Aerological Programme
ASCII	American Standard Code for Information Interchange
ASDAR	Aircraft to Satellite Data Relay
ATOVS	Advanced TOVS
AVHRR	Advanced Very High Resolution Radiometer
BBC	Black Body Calibration (METEOSAT)
BUFR	Binary Universal Form for data Representation
CBS	Commission for Basic Systems
CCIR	Consultative Committee on International Radio
CCSDS	Consultative Committee on Space Data Systems
CD	Compact Disk
CEOS	Committee on Earth Observations Satellites
CEPT	Conference Européenne des Postes et Télécommunications
CGMS	Coordination Group for Meteorological Satellites
CHRPT	Chinese HRPT (FY-1C and D)
CIS	Commonwealth of Independent States
CIIS	Common Instrument Interface Studies
CLS	Collecte Localisation Satellites (Toulouse)
CMS	Centre de Meteorologie Spatiale (Lannion)
CMV	Cloud Motion Vector
CMW	Cloud Motion Wind
COSPAR	Committee on Space Research
DAPS	DCS Automated Processing System (USA)
DCP	Data Collection Platform
DCS	Data Collection System
DIF	Directory Interchange Format
DOD	Department of Defence (USA)
DOMSAT	Domestic telecommunications relay Satellite (USA)
DPT	Delayed Picture Transmission
DRS	DCP Retransmission System (Meteosat)
DRT	Data Relay Transponder (INSAT)
DSB	Direct Soundings Broadcast
DUS	Data Utilisation Station (USA) (Japan)
DWS	Disaster Warning System (India)
EBB	Electronic Bulletin Board
EC	Executive Council (WMO)

ECMWF	European Centre for Medium range Weather Forecasts
ENVISAT	ESA future polar satellite for environment monitoring
EO	Earth Observation
EOS	Earth Observation System
EPS	EUMETSAT Polar System
ERBE	Earth Radiation Budget Experiment
ESA	European Space Agency
ESJWG	Earth Sciences Joint Working Group
ESOC	European Space Operations Centre (ESA)
EUMETSAT	European Meteorological Satellite Organisation
FAA	Federal Aviation Authority (USA)
FAO	Food and Agriculture Organisation (UN)
FAX	Facsimile
FXTS	Facsimile Transmission System (USA)
FY-1	Polar Orbiting Meteorological Satellite (PRC)
FY-2	Future Geostationary Meteorological Satellite (PRC)
GCOS	Global Climate Observing System
GIMTACS	GOES I-M Telemetry and Command System
GMR	GOES-Meteosat Relay
GMS	Geostationary Meteorological Satellite (Japan)
GNSS	Global Navigation Satellite System
GOES	Geostationary Operational Environmental Satellite (USA)
GOMS	Geostationary Operational Meteorological Satellite (Russ. Fed.)
GOS	Global Observing System
GSLMP	Global Sea Level Monitoring Programme
GPCP	Global Precipitation Climatology Project
GPS	Global Positioning System
GRAS	GNSS Receiver Atmospheric Sounding
GTS	Global Telecommunications System
GVAR	GOES Variable (data format) (USA)
HR	High Resolution
HRPT	High Resolution Picture Transmission
HIRS	High Resolution Infra-red Sounder
HSRS	High Spectral Resolution Sounder (MSG)
ICWG	International Coordination Working Group (EO)
IDCP	International DCP
IDCS	International Data Collection System
IDN	International Directory Network (CEOS)
IFRB	International Frequency Registration Board
INSAT	Indian geostationary satellite
IPOMS	International Polar Orbiting Meteorological Satellite Group
IR	Infrared
IRTS	Infrared Temperature Sounder (EPS)
ISCCP	International Satellite Cloud Climatology project
ISY	International Space Year
ITT	Invitation to Tender
ITU	International Telecommunications Union

ITWG	International TOVS Working Group
JMA	Japanese Meteorological Agency
LR	Low Resolution
LRIT	Low Rate Information Transmission
LRPT	Low Rate Picture Transmission
LST	Local Solar Time
MARF	Meteorological Archive and Retrieval Facility (EUMETSAT)
MCP	Meteorological Communications Package
MDD	Meteorological Data Distribution (Meteosat)
MDUS	Medium-scale Data Utilization Station (for GMS S-VISSR)
METOP	Future European meteorological polar orbiting satellite
METEOR	Polar orbiting meteorological satellite (CIS)
METEOSAT	Geostationary meteorological satellite (EUMETSAT)
MHS	Microwave Humidity Sounder (EPS)
MIEC	Meteorological Information Extraction Centre (ESOC)
MOCC	Meteosat Operational Control Centre (ESOC)
MOP	Meteosat Operational Programme
MPEF	Meteorological Product Extraction Facility (EUMETSAT)
MSC	Meteorological Satellite Centre (Japan)
MSG	Meteosat Second Generation
MSU	Microwave Sounding Unit
MTP	METEOSAT Transition Programme
MTS	Microwave Temperature Sounder (EPS)
MVIS	Multi-channel VIS and IR Radiometer (FY-1C and D of PRC)
NASA	National Aeronautics and Space Agency
NASDA	Japanese National Space Agency
NEDT	Noise Equivalent Delta Temperature
NESDIS	National Environmental Satellite Data and Information Service
NGDC	National Geophysical Data Centre (USA)
NH	
NMC	National Meteorological Centre
NOAA	National Oceanographic and Atmospheric Administration
NOS	National Ocean Service (USA)
NTIA	National Telecommunications and Information Agency (USA)
NWP	Numerical Weather Prediction
NWS	National weather service (USA)
OCAP	Operational Consortium of ASDAR Participants
OWSE-AF	Operational WWW Systems Evaluation for Africa
PC	Personal Computer
POEM	Polar Orbiting Earth Observation Mission (ESA)
POES	Polar orbiting Operational Environmental Satellite (USA)
PRC	Peoples Republic of China
PTT	Post Telegraph and Telecommunications authority

RA	Regional Association of WMO
RDCP	Regional DCP (Japan)
RMS	Root Mean Square
RMTC	Regional Meteorological Training Centre (WMO)
RSMC	Regional Specialised Meteorological Centre
S&R	Search and Rescue mission
SAM	Satellite Anomaly Manager
SAF	Satellite Applications Facility (EUMETSAT)
SAFISY	Space Agency Forum on the ISY
SARSAT	Search And Rescue, Satellite supported facility
SATOB	WMO code for Satellite Observation
SBUV	Solar Backscattered Ultra-Violet (ozone)
SEAS	Shipboard Environmental (data) Acquisition System
SEM	Space Environment Monitor
SEVIRI	Spinning Enhanced Visible and Infra-Red Imager (MSG)
S-FAX	S-band facsimile broadcast of FY-2 (PRC)
SFCG	Space Frequency Coordination Group
SMA	State Meteorological Administration (PRC)
SSP	Sub Satellite Point
SST	Sea Surface Temperature
SSU	Stratospheric Sounding Unit
S-VISSR	Stretched VISSR
TIROS	Television Infrared Observation Satellite
TOMS	Total Ozone Mapping Spectrometer
TOVS	TIROS Operational Vertical Sounder
U-MARF	United Meteorological Archive Retrieved Facility (EUMETSAT)
UHF	Ultra High Frequency
UK	United Kingdom
UMTS	a new international cellular telephone system
UN	United Nations
UNISPACE	3rd United Nations Space Conference
UN-OOSA	UN Office of Outer Space
USA	United States of America
UTC	Universal Time Coordinated
VAS	VISSR Atmospheric Sounder
VHF	Very High Frequency
VIRSR	Visible and Infra-Red Scanning Radiometer (EPS)
VIS	Visible channel
VISSR	Visible and Infra-red Spin Scan Radiometer
VLSI	Very Large Scale Integrated circuit
WARC	World Administrative Radio Conference
WCRP	World Climate Research Programme
WEFAX	Weather facsimile
WG	Working Group
WMO	World Meteorological Organization
WP	Working Paper

WRC97	World Radio Conference 1997
WV	Water Vapour
WWW	World Weather Watch
X-ADC	Extended Atlantic Data Coverage