

**REPORT OF THE TWENTY-SECOND MEETING
OF THE CO-ORDINATION GROUP FOR
METEOROLOGICAL SATELLITES**

**ANNAPOLIS, MARYLAND,
UNITED STATES OF AMERICA**

CGMS XXII

11 - 15 APRIL 1994

**REPORT OF THE TWENTY SECOND MEETING
OF THE CO-ORDINATION GROUP FOR
METEOROLOGICAL SATELLITES**

CGMS XXII

ANNAPOLIS, Maryland, United States of America

11- 15 APRIL 1994

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TWENTY SECOND MEETING OF THE CGMS

FINAL REPORT

A. PRELIMINARIES

A.1 Introduction

CGMS-XXII was convened at 9:00 a.m. on 11 April 1994 by Mr. Larry Heacock, Director, Office of Satellite Operations at NOAA/NESDIS who welcomed representatives from ESA, EUMETSAT, Japan, PRC, Russia, and WMO.

Dr. Alan Strong, representing the host, was invited to chair this initial part of the meeting. He introduced Captain Charles A. Martinek, Chairman of the Oceanography Department of the U.S. Naval Academy, who welcomed the CGMS participants to this institution and to the historic city of Annapolis emphasizing the high relevance of CGMS activities to the Navy and its importance for the world community.

A.2 Election of Chairman

Mr. Larry Heacock was unanimously elected Chairman of CGMS XXII, and Dr. Gérard Szejwach, Vice Chairman.

A.3 Arrangements for the Drafting Committee

The Drafting Committee was appointed and CGMS Members were requested to nominate rapporteurs to provide inputs for the final report.

A.4 Adoption of Agenda and Work plan of W/G Sessions

The Agenda (See Annex 2) was adopted. It was agreed that Working Groups I and III would work in series, in parallel to Working Group II.

A.5 Review of Action Items from Previous CGMS Meetings

The Secretariat reminded the participants of the permanent actions agreed in previous meetings, and then reviewed the outstanding actions, taking into account the input provided in EUM-WP-01, JAPAN-WP-01, USA-WP-34, and WMO-WP-02.

i) PERMANENT ACTIONS BY ALL PARTIES

CGMS recalled the following permanent actions:

- 1. Circulation of Satellite Operational Quarterly Reports and Image Photography.**

2. 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.
3. USA to issue quarterly to all other admitting authorities the consolidated DCP assignments.
4. All CGMS Members to inform users to register user stations within their area of responsibility.
5. CGMS Members generating cloud motion winds to check that monthly statistics are sent and received on a quarterly basis.
6. CGMS Members to consider a way to estimate the number of lost messages, and forward to the WMO, on a quarterly basis, statistics of the loss of DCP messages which are normally distributed on the GTS.
7. Each CGMS operator to monitor the unused IDCS channels for interference according to his own scheme, and prepare a report on results for CGMS. If practical, dates of test and channels to be tested will be coordinated (perhaps via the CGMS EBB) in order to obtain information on possible world-wide phenomena.
8. USA to distribute to CGMS Members updated files on solar activity when the compiled data becomes available.
9. CGMS Members to provide each other with information on their progress in the further development of archiving and retrieving systems.

ii) **OUTSTANDING ACTIONS FROM PREVIOUS MEETINGS**

ACTION 18.3 The Russian Federation to provide Meteor-3 temperature sounding data over the GTS as soon as practical.

Continuing. Preliminary sets of soundings have been delivered to ECMWF for evaluation. Russia informed CGMS of modification being implemented to the temperature retrieval scheme and of its intent to provide the data after these modifications and their validation. WMO offered its support for evaluation.

ACTION 18.5 WMO to obtain information on INSAT satellite image transmission schemes.

Reworded as follows: India to provide information on INSAT satellite image transmission schemes.

ACTION 18.11 The People's Republic of China and the Russian Federation to inform the Secretariat when IDCS channels will be implemented.

Continuing. PRC confirmed to CGMS XXII its intention to implement IDCS on FY-II, subject to confirmation of technical suitability.

ACTION 19.8 EUMETSAT to work with NOAA, the Secretariat of IPOMS, on behalf of CGMS in consideration of the roles to be played by the Group in relation to CEOS and IPOMS activities, and report to the next meeting of CGMS.

Closed. IPOMS finalized its activities in 1993. The United States circulated a final copy of the plan, "Fulfillment and Transition of the Objectives of the International Polar Orbiting Meteorological Satellite Group." With the completion of the Plan, and the approval by EUMETSAT Council of the EUMETSAT Polar System Preparatory Program, IPOMS was disbanded.

As defined by its Charter, CGMS will continue to serve as a forum on the operation and planning of polar-orbiting as well as geostationary meteorological satellites.

ACTION 20.12 (EUMETSAT Directory of Satellite Applications) CGMS Members are invited to submit proposals for a jointly produced publication focusing upon global applications and the benefit of meteorological satellite data.

Continuing. This was discussed further under Item H, and led to a new Action.

iii) ACTIONS FROM CGMS XXI

ACTION 21.01 USA to provide NOAA image calibration data to PRC and other interested members of CGMS.

Closed. Information has been provided and no further comments have been received by the USA.

ACTION 21.02 ESA to provide PRC with details of anomalies affecting Meteosat satellites and means used to cope with them.

Closed. Information has been provided during visit of PRC to ESA.

ACTION 21.03 USA to provide EUMETSAT with details of the GOES-6 GVAR dissemination schedules.

Closed. Test schedules for GOES central have been received.

ACTION 21.04 WMO to further define its contingency requirements as regards satellite services.

Closed. The CBS Working Group on Satellites met 7-11 March 1994 and discussed WMO contingency requirements for use by satellite operators. This issue has been further discussed by CGMS XXII under Item D.

ACTION 21.05 CGMS Members to consider mechanisms to provide coverage over the

Indian Ocean before CGMS XXII.

Continuing. The CGMS noted the progress of the development of the GOMS and of FY-2, as well as the status of the Meteosat satellites.

ACTION 21.06 WMO to notify the Government of India and the Russian Federation about the impact of the lack of coverage over the Indian Ocean.

Closed. The WMO Secretary-General wrote to the Permanent Representatives of India and of the Russian Federation. WMO informed CGMS that India was considering a MDD-type broadcast for INSAT imagery. Furthermore, Russia confirmed its plan for GOMS-1 and GOMS-2.

ACTION 21.07 CGMS satellite operators to review the WMO Satellite Data Requirements as to their achievability within currently planned systems, accuracy and mission schedules and within which anticipated time frame Members could wholly or partially satisfy the requirements. The results of this review should be received at the CGMS Secretariat by July 1993.

Closed. Comments have been formulated by Japan, EUMETSAT, and the USA, and have been addressed by CGMS XXII under Item E. WMO expressed its appreciation of this input for further refinement of these requirements.

ACTION 21.08 WMO to further refine the Satellite Data Requirements based on inputs from CGMS satellite operators.

Continuing. This will be reviewed in the framework of the CBS Working Group on Satellites.

ACTION 21.09 WMO to develop detailed satellite service requirements based on experiences learned during the OWSE-Africa Phases I and II.

Closed. This was discussed further under Item E.1.

ACTION 21.10 WMO to finalize its proposal for a training strategy involving sponsorship of specialized RMTC by satellite operators, and to identify corresponding needs before CGMS XXII.

Closed. This was discussed further under Item H.6.

ACTION 21.11 Satellite operators to comment on content and format of the present draft report on satellite ground receiving stations and make recommendations to WMO for future issues of the report by 30 September 1993.

Closed. No comment has been received by WMO. The report was finalized and distributed to WMO and CGMS Members as the Satellite Ground Receiving Equipment in WMO Regions, Status Report 1992,

SAT-11, Technical Document WMO/TD. No. 576.

ACTION 21.12 All CGMS Members to check the consolidated IDCS allocations list and report any discrepancies to the Secretariat by 31st May 1993.

Closed. Discrepancies were reported by Japan in letters dated 31 May and 14 Sept 1993. CGMS XXII decided to identify a new Permanent Action with respect to this matter :

Permanent Action 10 : All CGMS Members to monitor the IDCS allocation list and report any discrepancies to the Secretariat.

ACTION 21.13 USA to report the results of a study to sub-divide the IDCS Channel frequency range at CGMS XXII.

Closed. CGMS-XXII USA-WP-05 refers.

ACTION 21.14 WMO to notify OCAP about any relevant modification of its Terms of Reference resulting upon its agreed reporting channel to CGMS via WMO.

Closed. This action was completed through a letter from the Director of the WMO World Weather Watch (WWW) to the OCAP Chairman.

ACTION 21.15 USA to provide CGMS Secretariat with details of GVAR test plans together with the latest version of the GVAR simulator software.

Closed. A detailed report was provided in a handout to CGMS XXII.

ACTION 21.16 CGMS Members to confirm their agreement to the LRIT-Format by July 1993.

Closed. Noting the agreement from PRC (30 July 1993) and Japan (3 August 1993), all participants confirmed that agreement on this LRIT-Format. A new action was then generated :

" ACTION 22.01 WMO to distribute to all WMO Members a copy of the LRIT specification document to be provided by EUMETSAT. "

ACTION 21.17 All CGMS Members are requested to indicate planned introduction dates of LRIT.

Continuing. PRC responded on 30 July 1993, and USA indicated that LRIT will be introduced no sooner than 1996 for GOES.

ACTION 21.18 NOAA to provide CGMS Members with a draft global LRPT specification within the next 6 months.

Continuing. CGMS XXII USA-WP-25 refers.

- ACTION 21.19** USA to make further assessment of the impact of using an LRPT omnidirectional antenna, and report the results to CGMS Members.
- Closed.* Results have been reported to CGMS XXII in Working Group Session I.
- ACTION 21.20** EUMETSAT to inform NOAA and WMO about costs and any other related issues involved with the setting up of a CGMS Directory of Meteorological Satellite Applications.
- Closed.* Cost elements for such a publication are presented to CGMS XXII in EUM-WP-23.
- ACTION 21.21** CGMS Members to study the possible interference of the FY-2 S-Fax downlink with that of the NOAA HRPT, and report the results of these studies to the CGMS Secretariat by 1 August 1993.
- Closed.* Details from PRC dated 30 July 1993. Comment from USA dated 9 September, copied to PRC.
- ACTION 21.22** PRC to reallocate IDCP time slots on a 1.5 minute basis.
- Closed.* PRC confirmed its plan to do so.
- ACTION 21.23** The WMO to provisionally agree to the reallocation to the PRC of its 1110 IDCS prefix, and to confirm its decision to the CGMS Secretariat and PRC by 1 August 1993.
- Closed.* WMO letter dated 2 November agreed to this action.
- ACTION 21.24** CGMS Members to consider the possible technical measures for the reorganization of the IDCS to include the PRC and any other changes necessary to meet currently foreseen uses of the IDCS.
- Continuing.* This has been discussed further under Item F.1.
- ACTION 21.25** EUMETSAT and USA to provide PRC with technical information on calibration methods/procedures.
- Closed.* This information has been provided.
- ACTION 21.26** WMO (CBS) to confirm its request to CGMS members that they examine the feasibility of extending satellite based volcano ash monitoring and warning services to all parts of the globe.
- Closed.* This request was confirmed by the Director of WWW in a letter dated 20 August 1993. The response to this request was further discussed in Agenda Item H.2.

ACTION 21.27 CGMS Members to consider CEOS and CCSDS data formats and the CEOS catalogue system as a candidate for future archive and retrieval systems and report their findings to CGMS XXII.

Continuing. This was discussed within Working Group II under Item II/8.

ACTION 21.28 The CGMS Secretariat to ensure that a session of the Working Group on Contingency Planning is included in the Agenda of future meetings of CGMS.

Closed. See Agenda of CGMS-XXII

ACTION 21.29 The CGMS Secretariat to circulate the provisional terms of reference of the Working Group on Global Contingency Planning for comments before the meeting of CGMS XXII.

Closed. See CGMS-XXII EUM-WP-17

ACTION 21.30 EUMETSAT to prepare and distribute a document on a global Contingency Plan based on the "Woods Hole Concept" before the end of July 1993.

Continuing. The status of this issue was presented in CGMS-XXII EUM-WP-18 and discussed within Working Group III.

ACTION 21.31 All satellite operators to consider the above document, together with the Working Group reports from Woods Hole, Tokyo and Beijing meetings, and to prepare their position on this subject prior to the meeting of CGMS XXII.

Continuing. This was discussed within Working Group III.

ACTION 21.32 All satellite operators and WMO to establish lists of products and services needed on national, regional and global scales to serve as a check list when establishing contingency arrangements and to distribute them to other members before the next meeting of CGMS.

Continuing.

B. REPORT ON THE STATUS OF CURRENT SATELLITE SYSTEMS

B.1 Polar Orbiting Meteorological Satellite Systems

RUSSIA

Russia reported in RUS-WP-01 about the status of the METEOR polar-orbiting satellites, noting that METEOR-2-21, METEOR-3-5 and METEOR-3-7 were currently operational.

USA

The status of NOAA-J was presented in USA-WP-01. Modifications resulting from these analysis and results of the NOAA-13 failure review have been incorporated on NOAA-J and a launch date of September 28, 1994, has been requested. The current status of the in-orbit NOAA polar satellites as presented in USA-WP-23 does not pose a problem for continuing data coverage up to this launch date.

B.2 Geostationary Meteorological Satellite Systems

ESA

ESA described in ESA-WP-10 the anomalies affecting the Meteosat spacecraft, and related corrective measures, and gave further details in ESA-WP-04 about the anomaly affecting the IR and WV images of Meteosat-6. Meteosat-6 has been successfully launched on 20 November 1993, with an Ariane launcher from Kourou. During the commissioning of the radiometer unusual gain changes were observed in the IR and WV channels. The variation occurs not only from slot to slot but also within a slot. The VIS channel is not affected and provides excellent images. The observed anomaly has no effect on image rectification. Thus, image loops of the IR and WV channel provide geometrically stable images, but irregular variations in brightness temperature are observed. A series of investigational tests have been conducted to identify the cause. The most likely explanation to-date seems to be a combined effect of a rotating lens and contamination. Further tests are needed to validate the hypothesis. ESA reported in ESA-WP-09 about the XADC mission. With Meteosat-3 being operated at 75°W outside the view of the ESOC ground station, the XADC mission has been successfully conducted in a joint effort by NOAA and ESA/ESOC. The mission was implemented on a "best effort" basis, and after more than 1 year of operation the performance figure is above 98%

EUMETSAT

In its WP-02, EUMETSAT presented a status report on the Meteosat operational Programme (MOP) and the XADC satellites and their missions. It was recalled that the XADC mission was conducted under a tri-party agreement between NOAA, EUMETSAT and ESA. CGMS noted that Meteosat-3 appeared to have suffered from a higher than average solar activity during March 1994. It was noted by USA that a Canadian satellite had been affected in a similar way by solar activity during the period in question. Other members of CGMS were not aware of anomalous behavior of their satellites in this period. Noting the supply of GMS imagery relayed by GOES and Meteosat, Japan commented that whilst it was highly desirable that satellite operators globally distribute image data taken by other meteorological satellites, there was a clear need for coordination between the operator distributing, and the satellite operator providing the image data. This should enable to agree on the appropriate scheme for access and distribution, including the definition of the type of data to be distributed.

JAPAN

Japan described in JAPAN-WP-03 the status of the GMS satellite, noting that GMS-4 is the operational satellite at 140 °E since December 4 , 1989, and that the GMS-3 was kept at 120°E as the backup satellite. The operation of GMS-4, as shown in JAPAN-WP-02, was quite normal.

RUSSIA

Russia informed CGMS that the first GOMS/Elektro Satellite was prepared for launch in the second quarter of 1994. CGMS expressed its high interest, and decided the following action:

ACTION 22.02 **Russian Federation to forward for distribution by WMO, to appropriate WMO Members, the data dissemination schemes, frequency plan and transmission characteristics of the GOMS/Elektro Satellite, after its launch and in-orbit commissioning.**

USA

NOAA presented USA WP-02, which provided information on the status of GOES-7. In its 7 years of operation, GOES-7's VISSR has provided more than 500,000 images and innumerable soundings. USA-WP-24 provided the latest report on GOES-2, -3, -5, -6, and -7. Of these four remaining satellites, only GOES-7 is fully operational with all sub-systems fully functional.

The GOES-I Programme status was presented in USA-WP-03. The satellite was shipped to Cape Canaveral in January 1994 and has been prepared for a launch on an Atlas-1 launch vehicle on April 13, 1994. NOAA provided information on its post-GOES-I launch satellite implementation plan in USA-WP-28. NOAA plans to launch GOES-I to 80°W longitude, with its operational on-orbit position planned for 75°W beginning in January 1995. GOES-7 is likely to be the prime GOES-West satellite following the GOES-I/8 demonstration period. Depending upon the performance of GOES-I/8, Meteosat-3 may be moved to "standby" mode east of 75°W. The immediate need for XADC operations terminates 6 months after GOES-I launch, but it would be desirable to maintain the service as a backup until the launch of GOES-J. It is intended to terminate XADC within the first half of 1995.

CGMS welcomed this information and invited the Secretariat to establish a consolidated list of CGMS satellites. CGMS later took note of this list, as attached in annex (page 53-54 of this report).

ACTION 22.03 **The Secretariat to update as necessary, and forward to WMO a list of current and planned geostationary and polar satellites for distribution in the WWW Monthly Newsletter.**

C. **REPORT ON FUTURE SATELLITE SYSTEMS**

C.1 Future Polar Orbiting Meteorological Satellite Systems

EUMETSAT

EUMETSAT WP-03 recalled the background and main features of the METOP mission. It described the coordinated approach of space and ground segment activities of NOAA and EUMETSAT; noting that each operator would operate its own ground segment, its own satellites and would acquire data from its own satellite whilst in view of the ground segment.

Furthermore, each operator would acquire the global data from the other organizations' satellites for each "blind orbit" and exchange the global data from operational instruments. When possible, both organizations will coordinate their efforts for the standardization of data ingestion and pre-processing functions.

PRC

PRC informed the meeting that it is continuing to develop FY-1 polar-orbiting satellite series. FY-1, C, D have entered into the design phase.

RUSSIA

Russia presented in RUS-WP-03 the payload characteristics of the METEOR-3 and METEOR 3-M satellites, indicating that the discussion was still on-going about some instruments for the next generation METEOR 3-M. CGMS was informed that METEOR-3-8 was planned for launch in 1996, while METEOR-3M-1 and -2 were planned for 1997 and 1999 respectively. It was confirmed that METEOR-3M high resolution data will be disseminated in a HRPT-type format.

USA

The USA presented in USA-WP-33 the status and planned launch dates of the NOAA-K, L and M satellites. The current launch date for NOAA-K is June 1995. However, the USA brought the attention of CGMS Members to a potential problem with the NOAA-K circuit boards which may result in a 6-month delay (to January 1996) if the boards must be replaced.

C.2 Future Geostationary Meteorological Satellite Systems

EUMETSAT

EUMETSAT in WP-04 provided a status report on its Meteosat Transition Programme (MTP). CGMS noted that the satellite (similar to Meteosat 4, 5 and 6) would be integrated during the second half of 1994. Discussion on the actual launch date (currently end 1995) was in progress. WP-07 also presented a summary description of the new MTP ground segment, now under construction. The role of the MPEF, within the new ground segment was also explained. Meteorological products produced by the MPEF would be identical to those currently produced by the ESOC MIEC, but CMW would be produced every 1.5 hours instead of presently 3 hours. Products would be distributed in BUFR code as soon as possible.

EUMETSAT WP-05 described the current status of the Meteosat Second Generation (MSG) programme and summarized the system concept. CGMS recalled the channel characteristics of the MSG Spinning Enhanced Visible and Infra-red Imager (SEVIRI). CGMS also noted that ground processing of MSG data would be carried out using a network of Satellite Applications Facilities (SAF) supported by a central MPEF. The MPEF will produce products at a synoptic scale such as wind vectors and preliminary multispectral processing of the complete image data. The SAFs will concentrate on regional and specialized products.

JAPAN

In document WP-04, Japan described the future plans for its Geostationary Meteorological Satellite System. CGMS noted that GMS-5 will be launched in January/February 1995 and that JMA is preparing for the launch of a Multi-functional Transport Satellite (MTSAT) mission which would fulfill the needs of both of the meteorological service and Civil Aviation. The MTSAT is projected to be launched in 1999.

PRC

FY-2 was scheduled to be launched in the last half of April 1994. Unfortunately some unforeseen troubles resulted in the postponement of the launch. The new launching date will be indicated to CGMS in the future.

RUSSIA

Russia indicated in RUS-WP-04 that the manufacturing of GOMS-2 was underway. GOMS-2 will have a similar payload to GOMS 1, with an additional WV channel. It is planned for a launch in 1997 and a location at 76°E.

USA

USA presented a mission summary of its GOES-Next series in USA-WP-04. The GOES-Next series is planned to provide geostationary meteorological satellite coverage through 2010. The GOES-Next series will perform the following basic functions: acquisition, processing, and dissemination of simultaneous imaging and sounding data; acquisition and dissemination of Space Environment Monitor data; environmental data relays and relay of alert data from people, aircraft, or maritime vessels in distress.

Upon the conclusion of these presentations, the CGMS noted with appreciation the very active developments conducted now in multiple countries to continue and further improve the operational coverage from the geostationary orbit. The Chairman also suggested that a working group might be established in the near future to consider further maximizing the commonality between the future generations of satellites.

D. OPERATIONAL CONTINUITY AND RELIABILITY

D.1 Inter-regional planning (No matter was discussed under this item)

D.2 Global planning, including orbital positions

In WMO WP-3, the WMO discussed the status of their requirements for continuity of the space-based portion of the GOS. CGMS was informed that the CBS Working Group on Satellites had met 7-11 March 1994 and discussed WMO contingency requirements for use by satellite operators. In responding to a request from CGMS-XXI, the CBS Working Group on Satellites agreed to establish minimum requirements for products and services needed on national, regional and global scales and that such activities would occur within the Sub-group on Satellite Data, Products and Service Requirements.

CGMS was informed that the Final Report of the EC Panel of Experts on Satellites contained a comprehensive description of the space-based portion of the Global Observing System (see Annex I, "Consolidated Report" of the EC Panel Final Report). It noted that the comprehensive description was based on discussions and recommendations occurring at previous meetings of the EC Panel of Experts on Satellites. The CBS Working Group on Satellites believed that the description formed a basis for a reference system. The CBS Working Group on Satellites also agreed that the comprehensive description should be presented to CGMS to determine if it provided a necessary and sufficient description of WMO contingency requirements. If CGMS agreed, then the sub-group would develop an appropriate input for submission to the Working Group on Observations for inclusion in the Guide and Manual of the GOS.

ACTION 22.04 **CGMS Members to review the comprehensive description of the space-based portion of the global observing system, as given in Annex**

I of the Final Report of the Executive Council Panel of Experts on Satellites. CGMS Members to comment by 14 July 1994 if it formed a necessary and sufficient description of WMO contingency requirements.

E. METEOROLOGICAL SATELLITES AS PART OF WMO PROGRAMMES

E.1 World Weather Watch

WMO presented WMO WP-1, and CGMS noted that Mexico had hosted the Third WMO/ICSU International Workshop on Tropical Cyclones (IWTC-III) in Santa Cruz from 22 November to 1 December 1993. IWTC-III had made a number of recommendations concerning observing systems.

CGMS agreed to the following action items based on the recommendations:

ACTION 22.05 EUMETSAT to consider the possibility of moving a "spare" Meteosat satellite, if necessary, in order to provide coverage over the Indian Ocean.

It was noted that for the time being, no spare Meteosat satellite was available.

ACTION 22.06 NOAA and WMO to investigate the possibility of making Special Sensor Microwave Imager (SSM/I) data and products available on the GTS, so that they could be received by all NWP centres, tropical cyclone RSMCs and regional forecast offices.

ACTION 22.07 WMO to investigate mechanisms for having WMO Members place satellite image interpretation messages for all polar-orbiting satellites on the GTS.

CGMS recalled that at its XXI meeting, Members discussed the WMO data requirements contained in CGMS-XXI WMO-WP-08 and agreed on Action 21-07 to review these requirements. EUMETSAT presented in EUM-WP-24, and NOAA in USA-WP-29, a first set of comments.

WMO briefed CGMS, with WMO-WP-04, on the latest status in the development of its satellite data requirements. CGMS noted that the CBS Working Group on Satellites will further refine the WMO satellite data requirements presented at CGMS-XXI. WMO provided insights into the manner in which the CBS Working Group is considering interacting with the satellite operators. WMO discussed the objectives of the Sub-group on Satellite Data, Products and Service Requirements, those including:

- to build upon the work of the EC Panel of Experts on Satellites (ECSAT) in collecting, collating, keeping under review, interpreting and promoting to potential providers and their agents, statements of the satellite data, products and services required by WMO Members, and

- to reassure the user community that their needs are being properly interpreted and promoted;

CGMS noted that WMO will prepare a critical review of WMO requirements for satellite data, products and allied services, and of the capabilities to meet them.

CGMS welcomed the continuing effort by WMO to further refine its satellite data requirements through the critical review process and looked forward to viewing the progress made at CGMS-XXIII.

CGMS was briefed on the OWSE-Africa Final Reports for Phases I and II. The main purpose of OWSE-Africa was to improve the quality of the work of the centres involved in the project. According to the report from centres equipped with MDD receivers, the MDD has made a significant impact to their operations. WMO will continue to address the recommendations made in the Final Reports through the activities of the CBS Working Group on Satellites.

E.2 Other Programmes

JAPAN

In WP-05, Japan presented the status of data collection for International Satellite Cloud Climatology Programme (ISCCP) and Global Precipitation Climatology Project (GPCP) of the World Climate Research Programme (WCRP). ISCCP and GPCP data sets had been regularly produced and distributed in 1993 at a level close to 100%. WMO expressed its appreciation of the efforts of satellite operators in providing such a valuable database.

WMO

CGMS was briefed on the efforts by WMO with regard to small ground stations that would address the long-term needs of developing countries. It noted that the CBS Working Group on Satellites would develop and provide a draft functional requirement, specifications and training and maintenance plan for further consideration and use by WMO Members. CGMS agreed that this activity was important and noted that the CGMS efforts to define LRIT and LRPT formats should be taken into account when developing the small ground station specifications.

CGMS also discussed the need to address the immediate needs of developing countries, not presently equipped with any satellite receiving equipment. In this regard, CGMS also noted that a draft project plan for low-cost low-resolution satellite receivers had been developed and WMO was now in the process of seeking financial support for such plan. The project plan would serve to fill the gap between the present use and future use of new data formats (e.g., LRIT and LRPT) by the end of the decade.

CGMS agreed on a new action.

ACTION 22.08 CGMS Members to provide WMO, by September 1994, with comments on Appendix A of WMO-WP-07, related to the requirements for small ground stations.

Furthermore, CGMS took note of the main activities carried out by WMO concerning the use of satellites in the field of operational hydrology, as described in WMO-WP-10.

F. COORDINATION OF INTERNATIONAL DATA COLLECTION & DISTRIBUTION

F.1 Status and Problems of IDCS

EUMETSAT

In EUM-WP-06, the current status of utilization of IDCS channels was summarized. By February 1994 some 130 IDCPs were active in the Meteosat field of view, using 8 IDCS channels (I-6, 7, 12, 13, 14, 15, 16, and 18). Globally around 400 IDCPs are registered. CGMS noted that no significant interference problems were reported. The Secretariat distributed updated diskettes containing the consolidated IDCS allocations.

JAPAN

CGMS noted, in its WP-06, that JMA was implementing the services of International Data Collection System (IDCS) without serious problems. The messages from IDCPs are relayed by GMS-4 and entered into the Global Telecommunication System (GTS) through the JMA communication networks. Eight international channels (I-6, 7, 12, 13, 14, 15, 16, and 18) of GMS-4 DCP transponder have been operationally used to relay the messages. The international channels I-13 and I-16 of GMS-4 commenced to be newly used for EUMETSAT ships and for the support of the DCS of GOES-6 respectively, during 1993. The 209 DCPs (271 addresses) are registered with the GMS IDCS.

In WP-07, Japan recalled that under permanent Action Item 7, JMA has continued to monitor interference on the IDCS periodically, and has reported the monitoring results to CGMS Secretariat. The results of the monitoring from January through December in 1993 were presented.

CGMS noted that JMA had not observed any serious interferences on the all IDCS channels in the GMS coverage in 1993. However weak interferences were observed on channels 2, 3, 4, 5, 27, 28, 29, and 30. These interferences were too weak to interrupt IDCS operations. The status of interference on GMS IDCS channels was shown in tabular form together with the spectrum of interference. The weak interferences on channels 2, 3, 4, and 30 were still observed as of February 1994. CGMS complimented JMA on the clear format of its monitoring results.

In response to a request from WMO to be informed about non-conformant operation of DCPs (e.g., time clock discrepancies, frequency shift and offset) a new action was agreed.

ACTION 22.09 WMO to be included in the list of addressees informed about DCP non-conformant operations.

PRC reported in WP-04 that, resulting from coordination with Russian administration, the frequency bands to be used for the DCP system of FY-2 was confirmed, i.e., 401.1 - 401.4 MHz for domestic and 402.0 - 402.1 MHz for international DCP, in accordance with provisions developed by CGMS.

The USA proposed in USA-WP-05 three technical measures to consider, to cope with the expansion of the IDCS, in response to Action 21.24. The first recommendation in response to Action 21.24 was to re-allocate the IDCS identifiers to include the PRC. The second proposal

was to increase the number of IDCS channels by reducing the band width of channels 19 through 33, from 3KHz to 1.5KHz. The third recommendation was for CGMS Members to consider the future integration of 300 bps DCPs. Japan and EUMETSAT noted the benefits of these actions but indicated that their current DCS equipment would have to be replaced and that such a change would take many years. The Chair and WMO also noted these potential improvements and suggested that the recommendations be referred to WG-I for further technical discussion.

F.2 Ships, including ASAP

Japan reported that the 147 ship IDCPs (209 addresses) including ASAP were registered to the GMS IDCS as of 31 December 1993 and their operation was carried out quite normally. (JAPAN WP-08)

NOAA presented USA-WP-06, which listed DCPs assigned to DCS Automated Processing System (DAPS) channels.

F.3 ASDAR

Japan reported that JMA had extended eastward the area of responsibility for relaying from 180°E to 140°W on September 1993, supporting GOES IDCS. Consequently, the number of bulletins disseminated to GTS was increased (JAPAN WP-09).

In USA-WP-07, NOAA described the current status of the ADSAR program deployment stage for the operational units currently under contract. Of the eight operational ASDAR units previously deployed, two units have been withdrawn from operation. The working paper also included a list of DCP/GTS addresses which are currently assigned to operational ASDAR installations transmitting on international channel 18.

F.4 Dissemination of DCP messages (GTS or other means)

EUMETSAT

Document EUM-WP-21 presented a summary of the proceedings of the 2nd Data Collection System User Conference, held in Athens, Greece, from 14 to 17 September 1993. Whilst contributions to the Conference mainly reflected use of the Meteosat system, several more general recommendations, which may also be applicable to the International DCS, were also generated.

JAPAN

Japan reported that GMS DCS had received messages from 310 DCPs, which were processed at MSC and disseminated to JMA-HQ. (JAPAN WP-10)

USA

NOAA presented USA-WP-08, which listed the number of DCP channels received over DAPS International channel and disseminated via GTS and NOAA's National Meteorological Center. Under Agenda Item F.4, NOAA also presented USA-WP-22, which proposed the creation of an ad hoc CGMS working group on data collection systems. This group, as proposed by NOAA, would discuss the growth of DCS services and ways that CGMS members may accommodate this growth in the interests of the international research community. Issues the

group would explicitly address included the following: variable window sizes, media for international data exchange, and user interface documents.

Japan noted its reservation to NOAA's proposal for the creation of an Ad Hoc Working Group on Data Collection Systems, explaining that:

- JMA accepts the responsibility for relaying the data from the Data Collection Platforms whose data are useful for international meteorological services and other services charged to the JMA,
- A rapid increase in the number of the DCPs over the GMS coverage were not foreseen at the present time,
- The situation described in NOAA WP-22 is not necessarily common to all operators.

Japan proposed the following steps to solve the problems:

1. The problems on the regional DCS should first be itemized by NOAA and brought to the attention of all CGMS Members,
2. Satellite operators should assess these problems and report their assessment to other CGMS Members at the next CGMS Plenary or by exchange of letters,
3. Then CGMS Members would discuss the common problems, the action to be taken and the potential need for a special working group.

CGMS agreed that these points would, in the first instance, be referred to WG I for further consideration.

G. COORDINATION OF DATA DISSEMINATION

G.1 Dissemination via Satellite

EUMETSAT

EUM-WP-07 reported on the current status of the Meteosat Meteorological Data Distribution (MDD) mission. CGMS was informed about the planning of a third MDD uplink station, to be located in Toulouse, France, whose schedule of mixed alphanumeric messages and graphical products would be formulated to meet the growing requirements of Africa and surrounding regions. In due course, products developed within Africa would also be disseminated by this uplink station.

In its WP-08, EUMETSAT described the status of the technical control of the access to High Resolution Image data from Meteosat. CGMS was informed that encrypted test formats are currently disseminated, and the encryption/decryption capability is expected to be fully operational by the end of 1994. In the meantime, a registration and licensing procedure was being developed, with the objective of a full implementation around late 1995.

JAPAN

Japan informed CGMS, in JAPAN-WP-11, that a revision of the stretched VISSR data format for GMS had been issued in October 1993, and will be implemented for both GMS-4 and GMS-5 satellites after commencement of GMS-5 operation in May 1995.

RUSSIA

Russia presented in RUS-WP-05 the processing of raw GOMS data for low resolution imagery (WEFAX) dissemination. CGMS noted that further details on formats, catalogue, and dissemination schedule are expected to be provided to the users about 3 months after launch and check-out.

USA

In response to CGMS XXI Action Item 21.18, the USA-WP-25 on the new LRPT format was presented. The USA noted that 2 proposed applications were presented (a 3km application and a 1km application) and that these options had been formulated after the results of a user survey had been evaluated: the survey indicated a user preference for high-resolution data. The USA indicated that the service would be the 1km application which would require a data compression scheme. WMO emphasized the essential requirement that the LRPT should facilitate the implementation of low-cost user stations.

CGMS Members concurred with the need to continue the broadcast of real time satellite data for low cost ground stations. USA and EUMETSAT urged CGMS to adopt the proposed format as the basis for future broadcasts for low cost ground stations.

CGMS agreed to the following actions :

ACTION 22.10 USA/NOAA to distribute by 1 July the definition of the LRPT format.

ACTION 22.11 CGMS Members are requested to notify the Secretariat of their agreement on the proposed LRPT format by 1 December 1994.

NOAA informed CGMS on the status of the NOAAPORT broadcast system, described in USA-WP-26.

G.2 Dissemination via GTS or other means

WMO expressed concern that image data from geostationary satellites were usually not available outside the footprint of the satellites, and mentioned that the use of INTERNET was only a provisional by-pass to this limitation. CGMS acknowledged the need for a global exchange of certain image data and agreed to give an action to WMO.

ACTION 22.12 WMO to articulate their operational requirements for the global exchange of satellite image data, to consider how best to achieve such exchange and to make recommendations as appropriate to CGMS.

H. OTHER ITEMS OF MORE GENERAL INTEREST

H.1 CEOS Global Satellite Observation and Information Network

USA

NOAA reported, in USA-WP-09, that CEOS was addressing the issue of global satellite observation and information network. WMO enquired about the possible relevance of this issue to the GTS. CGMS took note of this initiative, pending further information.

H.2 Applications of Meteorological Satellite Data for Environment Monitoring

USA

NOAA briefly reported in USA-WP-10 about the soil wetness index derived from DMSP SSM/I data, and its application in environmental monitoring. NOAA accepted the following action.

ACTION 22.13 USA to provide the Russian Federation with existing application notes on the use of soil wetness index derived from SSM/I.

NOAA introduced USA-WP-30 describing the activities of NOAA and other U.S. Government agencies in the implementation of an operational volcano hazards alerting plan. NOAA suggested that CGMS Members review this plan and develop similar material or regional plans which could extend satellite based volcano ash monitoring and warning services throughout the world. It was also noted that initiatives were being considered among EUMETSAT Members in this area. WMO expressed its high appreciation of the efforts of CGMS Members to set up an operational monitoring programme.

CGMS endorsed the development of a plan which would be globally applicable since both Japan and EUMETSAT have under consideration the provision of such warning services. To that end, WMO and NOAA accepted the following action.

ACTION 22.14 WMO and NOAA to collaborate on the development of a plan concerning volcano ash satellite monitoring, for submission to WMO/CBS for review and eventual implementation.

PRC

CGMS thanked PRC for the images of Philippine volcano eruption presented within PRC-WP-07.

USA

CGMS took note of USA-WP-31 describing the planned satellite support to the Global Ocean Observing System, based on national satellite programmes utilizing oceanic sensors.

H.3 Search and Rescue (S&R)

USA

CGMS took note of two reports, Cospas-Sarsat Information Bulletin no. 8, and Cospas-Sarsat System Data no. 17, which were recently published by the Cospas-Sarsat Secretariat. The status and activities of the International Cospas-Sarsat Programme were outlined in the documents.

CGMS took note of information paper (USA-WP-12) which was provided as NOAA's update

to the CGMS membership on the status of and developments within the International Cospas/Sarsat Programme. It described the current structure and aims of existing Task Groups which play important roles in the further development of the Cospas/Sarsat system.

H.4 Anomalies from Solar and Other Events

The Chairman reported that the origin of a catastrophic failure of a Canadian satellite was thought to be a high-energy electron flow rather than a solar event (see also section B.2 - references to the frequency of Meteosat-3 anomalies in the same period).

H.5 Directory of applications

EUMETSAT

EUMETSAT recalled that a "EUMETSAT Directory of Meteorological Satellite Applications" had been presented to CGMS XX and CGMS XXI, with the suggestion that a similar document be produced at CGMS level, illustrating the multiple applications developed by CGMS Members. Responding to Action 21.20, EUM-WP-23 presented some cost elements for such a publication. CGMS noted the high interest expressed by CBS/WG-Sat for such a publication, and NOAA suggested its further consideration. CGMS agreed to investigate this idea, building on the experience of EUMETSAT, and decided upon two actions.

ACTION 22.15 All CGMS Members to forward to EUMETSAT a list of topics to be included in a CGMS Directory of Meteorological Applications, by 1 July 1994.

ACTION 22.16 EUMETSAT to collect the suggestions of all Members, to draw up on this basis a global outline of a CGMS Directory referring to a target audience and to propose a procedure to implement this project.

It was noted that the primary audience should be the Permanent Representatives with WMO and their national authorities, but that a version of this publication might be helpful for training purposes, provided it is affordable and scientifically up to date.

H.6 Other items of interest

ESA

ESA informed CGMS about the availability of the CD-ROM TERRA, containing animated sequences of significant Meteosat images, prepared for a wide audience.

PRC

CGMS noted that the International Conference on Satellite Meteorology in Asia-West Pacific Region might be postponed, due to the postponement of the launch of FY-2. Japan informed CGMS that it was willing to cooperate with PRC on the organization of this conference.

CGMS also noted that Japan was preparing an International Seminar on the utilization of the extended information from the Geostationary Meteorological Satellites. JMA intended to invite persons in charge of GMS data receiving and application programmes in the GMS coverage area. The objective of this seminar is to enhance the utilization of new GMS-5 image data which will be available from May 1 next year.

WMO

CGMS recalled that the WMO Strategy for Education and Training had been presented at CGMS-XXI. At that time, the three objectives of the Strategy were explained including building on the existing infrastructure, focusing on the developing countries and anticipating future trends in satellite data applications. CGMS-XXI had expressed interest in the proposal to establish six specialized satellite centres at RMTCs. With regard to the proposal that each satellite operator adopt at least one of the six centres, CGMS-XXI had agreed in principle with the Strategy and also to a willingness to further discuss the proposal with WMO. CGMS-XXI had indicated that WMO should further identify specific needs to aid potential CGMS supporters in evaluating resource requirements for such sponsorship, together with proposed implementation dates. Appendix A of document WMO-WP-06 provided an outline of these requirements, in response to this action.

CGMS noted that the CBS Working Group on Satellites had reviewed and updated the list of experts in satellite applications who could assist with implementing the training strategy via participation in special seminars, "train the trainer" activities, and development of computer assisted learning modules on satellite applications.

ACTION 22.17 CGMS Members to review the updated list of experts in satellite applications and provide to WMO the names of additional experts.

CGMS was informed that a set of specifications for Specialized Satellite Training Centres at RMTCs had been developed and that a preliminary analysis of the relative suitability of the various RMTCs as candidates for designation as Specialized Satellite Training Centres had been conducted.

CGMS noted the preliminary conclusions that identified the RMTC's best suited at present for enhancement to Specialized Satellite Training Centres.

In addressing a mechanism to identify costing information more clearly, WMO had agreed that a trial project should be implemented as soon as possible for one or two Specialized Satellite Training Centres. This would necessitate the involvement of the satellite operators and any other sponsors.

CGMS thanked WMO for its efforts in compiling the information. All CGMS Members were supportive of the principles proposed and found the information well focussed and providing a valuable input.

EUMETSAT informed CGMS about new plans for training first within EUMETSAT Member States, but also in developing countries and in particular in Africa. Training material would be developed and made available to CGMS in line with the recommendations of the WMO CBS Working Group on Satellites.

In order to achieve progress on this matter, all CGMS Members agreed to investigate possibilities to co-sponsor Specialized Satellite Training Centres and report their findings and recommendations at the next meeting of CGMS. WMO agreed to provide any support required by the other CGMS Members during the review of the WMO proposal.

ACTION 22.18 **CGMS Members to investigate possibilities to co-sponsor Specialized Satellite Training Centres and report to CGMS-XXIII.**

Concluding discussion on this section, CGMS expressed its hearty congratulations to NOAA for the faultless launch of GOES-I which occurred on Wednesday 13 April, 06.04 UTC.

PARALLEL WORKING GROUP SESSIONS

WORKING GROUP I : TELECOMMUNICATIONS

I/1 Coordination of Frequency Allocations

EUMETSAT presented WP-09, which was one of many papers at the recent SFCG on the protection of passive sensors. The goal of the paper was to explain why the measurements of these instruments must be done in the 54.25-58.2 GHz band, and why they must be protected from interference from other services. Working Group participants agreed on the need for this issue to be on the agenda for WRC-97, at which the meteorological satellite operators should present a common position. Working Group participants noted that the SFCG and WMO had important roles in presenting a unified and effective position, and that various working groups have been created to handle these matters.

The Working Group recommended that the CGMS Plenary express the following recommendations to the SFCG, WMO, and ITU:

- 1) **Protection for the existing passive microwave sounding channels used by the Meteorological Satellite Service (Met SS) must be guaranteed by proper ITU regulation methods.**
2. **Exclusive allocation for passive Earth exploration and space research services is requested for the sensor frequencies wherever possible.**
3. **Additional exclusive allocation for passive observations is also requested for the band 60.4-61.2 GHz to accommodate the future upgrading of the Meteorological Satellite Services (Met SS).**
4. **The existing and planned utilization of the following bands, in which both Fixed and Mobile Services are assigned as primary users, should be investigated:**
 - 47.2-50.2 GHz;**
 - 50.4-51.4 GHz;**
 - 59.0-64.0 GHz**

PRC WP-04 informed the working group that, after coordination with the Russian administration, the frequency band used for FY-2A's DCP network will remain unchanged and follow the original frequency assignment of the network, at 401.1-401.4 MHz for DCPs and 402.0-402.1 MHz for IDCPS. It was agreed that both Russia and the PRC would use the 402.0-402.1 MHz IDCPS band.

In RUS WP-06, Roshydromet presented its position on frequency allocation matters pertaining to GOMS-1 and GOMS-2. The paper noted that the GOMS-1 was prepared for launch, related space and ground segments were prepared for operation, and appropriate notifications to radio administration authorities had taken place. Roshydromet also expressed its current concern over SFCG Resolution 12-2, which proposed the reallocation of Met SS bands for space-to-Earth and Earth-to-space communications systems. Working Group participants noted that the SFCG

Resolution was a long-term one unlikely to affect GOMS-1 and GOMS-2 during their in-orbit lifetimes. Roshydromet and other working group participants therefore agreed that the reallocation of frequency in this band could be supported, with the understanding that it would allow application of current or presently planned systems at least until 2010.

USA-WP-13 summarized the activities of the 1993 World Radio Conference (WRC-93). WRC-93 was the first of a newly-structured meeting format which will focus agendas on a limited segment of frequency allocations or types of services. WRC-93 limited its discussion to finalizing the agenda for WRC-95 and to setting a preliminary list of topics for WRC-97.

For WRC-95 only the 13.75-14 GHz band will be discussed relating to meteorological satellites. Issues in this band are limited to the Topex-Poseidon mission and Tropical Rainfall Measurement Mission (TRMM). The Fixed Service was introduced in this band at the World Administrative Radio Conference-92 (WARC-92) but will protect the Topex-Poseidon and TRMM projects through the expected life of each mission.

Many topics involving the Met SS are preliminarily planned for WRC-97. Depending on the progress achieved at WRC-95, some of the meteorological satellite topics may be postponed until WRC-97. Possible issues to be addressed include passive bands above 50 GHz, upgrading the 401-403 MHz band to a primary status, coordinating distances for meteorological satellite ground stations with the Fixed and Mobile SSs, and various activities regarding the Earth Exploratory Satellite Service in the 8-20 GHz region.

NOAA presented USA WP-14 as an information paper describing the provisions of the ITU's International Radio Regulations as they relate to satellite coordination. The paper noted that, in the case of non-geostationary satellites, it is common for multiple spacecraft to simultaneously appear in the antenna beam width of a ground station. Frequently, both parties agree that predicted levels of transitory interference are acceptable, particularly when relatively brief and infrequent. This is likely to be the case with any potential interference between FY-2 S-FAX and NOAA HRPT.

NOAA and CMA informed the Working Group that they had consulted with one another to avoid future problems over potential frequency interference. The PRC representative stated that, since FY-2's S-FAX was an experimental, domestic system, CMA would take appropriate actions during NOAA satellite passes to prevent any interference.

With WMO WP-12, the working group was informed of WMO activities with regard to radio frequency allocation. WMO was of the opinion that its Members must act together to protect spectrum needed for meteorological activities and therefore WMO Members should:

- a) make contact, within their own countries, with the organizations which establish national positions on spectrum management issues.
- b) share, through appropriate WMO working groups, any information they may gain regarding commercial efforts to share or take over meteorological spectrum.
- c) attempt to place persons sympathetic to the needs of meteorology on national delegations to ITU conferences.

- d) continue to seek registration by their national administrations of satellite ground stations used in meteorology, with a view to reflecting active usage in ITU's Master Frequency Register.
- e) encourage WMO participation in activities of the ITU and the Radiocommunications Sector.
- f) seek to provide to the WMO the names, addresses and affiliations of individuals in their countries who are involved with national spectrum management and who are sympathetic to the concerns of science in general and meteorology in particular.

The working group noted that WMO felt it extremely important to have an official position with regard to frequency allocation and to distribute such to WMO Members to attempt to harmonize national policies. WMO indicated that it would be pleased to utilize any information CGMS may develop with regard to frequency allocation in formulating its official position in order to meet the WMO objectives.

The working group also noted WMO's concerns with the possible loss of frequencies for passive microwave sounders. It was informed that WMO would prepare a master list of satellite frequencies necessary for present and planned applicable remote-sensing instruments utilizing microwave frequencies.

The Working Group expressed its appreciation to WMO for its effective frequency management advocacy efforts. Working Group members agreed to provide updated user, ground station, and frequency usage information to the WMO. This action would be taken to assist the WMO in its frequency management efforts.

ACTION WG I.1 Satellite operators to provide to the WMO information on users, ground stations and frequency use, by 30 May, preferably in a database format.

I/2 Results of the SFCG - Secretariat Report

In its WP-10, EUMETSAT reported on the issues relevant to the Met SS and meteorological sensor frequencies. These issues included Met SS in the 1670-1710 MHz band; frequency allocations for passive sensors on spacecraft; active sensors on Earth exploration satellites; SFCG data bases; and wind profiler issues.

It was noted by working group participants that WRC-97 will include numerous agenda items of interest to the meteorological satellite operators, and that satellite operators should work closely with their national administrations to have their support at future WRCs. Working Group participants commended the SFCG on its effective role in these efforts, and its advocacy for Met SS frequencies and issues.

I/3 Electronic Bulletin Boards

In USA WP-15, NOAA described its Electronic Bulletin Board Service and access for satellite data users. Inquiries or comments should be addressed to the NOAA/NESDIS Data Collection

and Direct Broadcast Branch.

NOAA presented in USA WP-27 information on its new Home Page Mosaic server system, which is an entry point for Internet users to a wide range of information about NOAA programmes and data.

CGMS was informed that the CGMS.PLENARY bulletin board on OMNET had changed due to the change in OMNET service that occurred in March 1994. The CGMS.PLENARY bulletin board had become a CGMS.PLENARY mailing list. Any CGMS Member on the member list in Annex X can post a message to the mailing list. Such a message would automatically be sent to the mailbox of all members of the list. The messages would have the same privacy as any other message posted to a personal mailbox. In order to send a message, the procedure would be to type "CGMS.PLENARY" in the "To:" line.

The CGMS.WINDS bulletin board has been converted to a mailing list maintained by WMO. This procedure was deemed appropriate due to the large number of Members, many of whom are not CGMS Members, and also due to the many address changes. Messages to be posted to CGMS.WINDS Members must first be sent to D. HINSMAN who will then post the message to CGMS.WINDS.

During discussions within the Working Group on Telecommunications, it was recommended that a mailing list for radio frequency matters be established. WMO agreed to construct the CGMS.FREQUENCY list. Procedures similar to CGMS.WINDS will be followed.

Prior to 30 May 1994, WMO will exercise the message forwarding capability for all three mailing lists (CGMS.PLENARY, CGMS.WINDS and CGMS.FREQUENCY) to allow its members to observe the procedures.

ACTION WG I.2 CGMS participants to provide to the WMO by 15 May 1994 the names and Internet or Omnet addresses of staff interested in a CGMS. FREQUENCY message forwarding capability.

ACTION WG I.3 WMO to develop a CGMS.FREQUENCY message forwarding capability for interested CGMS participants prior to 30 May 1994.

I/4 Other Issues

In USA WP-22, NOAA recommended the creation of an ad hoc CGMS-related group on Data Collection Systems. NOAA recommended the creation of a dedicated group to study a number of important DCS issues: variable transmission rates; variable window sizes to accommodate user requirements and improve channel utilization; and user interface documents. But most importantly, NOAA recommended the creation of a dedicated group to accommodate the broader growth of DCS services and ways in which CGMS Members may best accommodate and coordinate this growth in the interests of the international research community. Noting that the scope of Working Group I was limited only to technical matters, this proposal was referred to the Plenary session for further consideration. Concerning technical matters related to IDCS, it was agreed that these issues would be regularly included in future Working Group discussions.

WORKING GROUP II : SATELLITE PRODUCTS

II/1 Image processing techniques

ESA WP-02 showed that ESA's prior methodology for image rectification was limited due to processing and time considerations, and user requested modification to the approach. The new approach involving bi-cubic spline resampling is currently operating on Meteosat 3 and 4. The improvement in mean image RMS errors is from 0.6 to 0.2 pixels. The United States agreed to investigate the utility of ESA's approach and sought a point of contact, which was provided.

ESA WP-03 described a more effective work station development, based on the transputer, for display of high resolution images. This has resulted in the ability to produce hourly winds. Validation of the results at a number of NWP sites is planned.

ESA-WP-07 addressed the Applications and Capabilities of the Meteosat image processing system. ESA directed interested parties to the author, Mr. F. J. Diekmann.

II/2 Satellite Data Calibration

ESA WP-1/US-WP-17 described the results of a joint study involving ESA, NESDIS and the University of Wisconsin. The approaches are documented in a NOAA/NESDIS report in 1993 and result in significantly improved calibration of radiance measurements. This is a real time technique which improves the radiances all through the day, thus improving all derived products. No effort has yet been undertaken to compare GMS and GOES. The Working Group formulated a recommendation to the plenary.

Recommendation : Periodic Meteosat and GOES cross calibrations of radiance measurements should be implemented operationally in real time .

ACTION WG II.1 EUMETSAT and NOAA to investigate the use of polar orbiters to normalize geostationary satellite calibration and report at CGMS XXIII.

ESA WP-05 discussed the use of radiosonde humidity measurements to calibrate satellite water vapour measurements. While NWP experts were involved, it was suggested that ESA contact two additional experts, John Nash (UK) and Mel Gelman (USA) who have extensive experience in radiosonde performance. The United States also noted the status of implementing improved water vapour measurements at high atmospheric levels for radiosondes.

JAPAN WP-14 focused upon monitoring of GMS visible image data for purposes of calibration. It demonstrated a long term decrease in GMS measured visible reflectance. CGMS Members were invited to review this paper.

ACTION WG II.2 CGMS Members to forward to Japan, and to the Secretariat, their comments on GMS visible reflectance monitoring.

PRC WP-05 presented a plan to establish radiometric calibration fields by 1996. PRC will describe in detail the kind of assistance it requires.

ACTION WG II.3 NOAA/EUMETSAT to respond, to the extent possible, to PRC's requests for calibration assistance.

PRC is planning to establish calibration fields for quantitative processing of satellite remote-sensing data and the absolute radiometer calibration of in-orbit satellite sensors. Two land fields, Du Huang and Ge Ermu (one is for backup), and one water field, Qing Hai Lake, have been selected. All of these fields are in the North-West China.

USA-WP-16 identified work done by NOAA in reprocessing of AVHRR data in support of climate and climate change studies. Two technical reports are identified and are available from NESDIS on request.

RUSSIA WP-07 reported on the status of development of an operational calibration scheme for GOMS in window channel. Russia reported on the different approaches tried and the determination of the best approach. It drew attention to the need for on-board calibration in future operational systems. There is a desire to use Meteosat 4 and GOMS (when launched) as a pathfinder activity. Russia indicated that it will contact EUMETSAT at the proper time, to coordinate this effort.

II/3 Wind Vectors

ESA-WP-11 reported that after 1 year of testing the water vapor winds for Meteosat were quasi operational and available four times per day. EUMETSAT will recommend operational status for May 1994. The ESA scheme uses IR and water vapor radiances to derive height assignments. The United States reported a complementary approach which enabled the definition of deep layer winds from cloud-free areas; which can be useful in NWP and incorporates the notion of deep layer mean. ESA also produces such winds but these are not yet disseminated.

EUMETSAT WP-11 reported on the success of the Wind Workshop hosted by Japan. WMO's support had been very welcome as had been the excellent organization by Japan. A session focused on the latest results of the extraction of cloud motion winds. Australia, not a satellite operator, is also extracting winds. Dramatic Japanese improvement was noted. Research in stereo winds, rapid scan, height assignment, QC and verification, and impact studies by NWP groups were reported. The workshop was very successful in bringing together wind producer, users, and recorders. A third Workshop is planned for late 1995 in Geneva or Darmstadt.

EUMETSAT WP-12 addressed verification for cloud motion winds. An improvement was demonstrated for EUMETSAT and GMS winds.

EUMETSAT WP-13 discussed the optimization of verification procedures for cloud motion winds. It drew attention to the quality control of verification data and their use in the verification scheme. The workshop recommended careful selection of such reference data (radiosonde, pilot and AIREP data).

WG members noted the potential use of NWP products be considered as a significant, quality controlled source of verification data for real time use.

EUMETSAT WP-20 presented a proposal for the establishment of a CGMS WG on Satellite Winds. The working group would report to plenary of CGMS. The Winds WG would have core representation from each CGMS Member and the Winds WG would continue to have workshops involving the user community. WG-II discussed these issues, agreed to minor modifications to the Terms of Reference, and expressed following the Recommendation and Action.

Recommendation: CGMS to establish a Winds Working Group under the considered Terms of Reference (as amended).

ACTION WG II.4 CGMS Members to identify Core Representatives to the Winds Working Group by October 1, 1994.

JAPAN WP-16 introduced the improvements of GMS high-level cloud motion winds since 1990. The Working Group enthusiastically noted this improvement.

In JAPAN-WP-17, Japan presented the current state of water vapour wind extraction from GMS.

RUSSIA-WP-08 presented a brief report on the wind extraction system for GOMS. Three successive IR and one visible image will be used to generate winds.

II/4 Vertical Sounding

JAPAN-WP-15 discussed the status of the TOVS processing system in Japan. The new retrieval system has made significant improvements possible. The spatial resolution of this product is higher than that provided by NOAA. These data are not yet available through GTS.

EUM-WP-14 discussed progress with ATOVS software development. This is being done in cooperation with NOAA. The software development lags the projected availability of the satellite, but every effort is being made to reduce the gap.

RUSSIA-WP-11 presented information on the development of TOVS processing software in the Hydrometeorological Center in Russia. Results are variable with some temperature retrievals being better and some not as good as those received from GTS. Humidity retrievals are generally better.

USA-WP-32 discussed the work of the ITOVS Working Group (ITWG). The group has been active in its participation in the CBS Working Group on Satellites. In the last session, the ITWG recommended that a full resolution archive of level '1B' data be maintained in support of climate studies, with open access at minimal cost and that operators provide information on expected error characteristics. ITWG had noted that local and regional operational use of TOVS data is dependent upon plans to continue direct broadcasts. Plans to continue direct broadcasts were strongly encouraged by the ITWG. It was recommended that ATOVS software be made generally available and it was recognized by the WG that long term support was necessary. The USA noted that every effort was being made to deliver an initial useful package for ATOVS and an improved package will be distributed later. ITWG continues to encourage all efforts for new

vertical sounders with higher spectral resolution. ITWG volunteers to provide satellite experts for education and training. ITWG also encouraged CGMS to utilize the ITWG expertise, where appropriate, regarding remote sensing issues and training. The Working Group II welcomed the recommendations of the ITWG, and expressed a recommendation to the plenary.

Recommendation: The CGMS is invited to note and support the recommendations formulated by the ITWG, and in particular to give due consideration to continuing direct broadcast services in the future.

II/5 Other Parameter Extraction

JAPAN WP-13 described the plans for GMS products in detail including visible, water vapour, and IR channel based products, their frequency and source of availability. Japan plans to use only the split window for deriving precipitable water. NOAA plans to use a new 3-channel technique involving data from the water vapour channel.

ACTION WG II.5 NOAA to provide to interested parties documentation of the new 3-channel technique for precipitable water derivation, following establishment of GOES I useful performance.

RUSSIA WP-09 provided information on the derivation of SST and precipitable water from Meteor and NOAA measurements. It provided details of the processing schemes and results for operational production.

RUSSIA WP-10 described the production and meteorological application of remote sensing data with high spatial resolution (1-10 Km). This paper is a review of certain studies such as SST development, AVHRR, and side-looking radar. It was hoped the paper would provide a useful reference. Side-looking radar is not now available for operational support.

RUSSIA WP-12 discussed the use of AVHRR in estimating cloud parameters and precipitation intensity. This paper is a summary of work over the past 2 years. Work has also included the use of conventional radar data for validation of results.

USA WP-18 was an overview of NOAA satellite data uses in providing assistance to disaster mitigation.

II/6 New Products & their use in Numerical Weather Prediction

ESA WP-06 was a reproduction of a recent paper on upper tropospheric observations from Meteosat and their comparison with ECMWF forecasts. One result is that the ECMWF model is too "moist" in subtropical latitudes. This highlights the need for numerical weather prediction models to use more effectively the water vapour measurements from satellites. It furthermore highlighted the potential impact upon climate models. NOAA also highlighted the importance of upper tropospheric measurements needed from Meteosat and GOES for climate purposes. ESA and NOAA reported that they are conducting an upper-troposphere humidity water vapour experiment which began in March 1994. It was noted that before satellite water vapour use in numerical models can be effective, better parameterization in models is needed and that these efforts should be accelerated.

ESA WP-08 informed on the development of an enhanced upper tropospheric humidity product.

EUMETSAT WP-15 described EUMETSAT research activities noting, in particular, those concerned with SSM/I and ERS-1 data. The paper also introduced the Satellite Application Facility concept.

USA WP-19 described new products being derived from the TOVS and DMSP operation sounding system and temperature and water vapour products, including winds, from geostationary satellites.

II/7 Coordination of Code forms for satellite Data

USA-WP-20 described the CEOS Working Group on Data, its structure and composition, its responsibilities, the focus of its efforts, progress with its work and focal points. The WG noted the importance of using lessons learned in codes and related matters from GTS, as well as the importance of long-term experience of operational archive.

USA WP-21 proposed formats for level 1B data sets from NOAA K,L,M and requested comments from CGMS Members.

ACTION WG II.6 CGMS to provide comments on the proposed NOAA K,L,M 1b format direct to NOAA by August 1, 1994.

II/8 Coordination of Data Formats for the Archive and Retrieval of Satellite Data

EUMETSAT WP-16 discussed the MTP archive and retrieval facility and the approach to data formats. The WG-II discussed the recommendations made in the paper, which are summarized below:

- a. That consideration be given by CGMS towards adopting standard data formats for data exchange.
- b. CGMS Members should review the detailed data formats specified by CEOS and CCSDS and discuss the adoption, for the future, of a common data standard amongst CGMS members for data exchange.
- c. CGMS Members should consider the use of one of these standards for future archives.
- d. CGMS Members study the CEOS catalogue system and to consider to support the CEOS International Directory Network (IDN) and to consider to construct and maintain Directory Interchange Formats (DIF) for inclusion in the CEOS IDN.
- e. CGMS Members be requested to provide information on plans concerning the introduction of new archive and distribution media.

- f. And that CGMS should regularly discuss the developments in the field through further consideration of information about CEOS and CCSDS work.

Following the presentation of these recommendations, the WG agreed that CGMS should continue to be kept apprised of the on-going standards development under CEOS (and other groups). Recommendations (c) to (f), with emphasis on items (e) and (f), were supported by the WG. The Chairperson noted that at previous CGMS meetings (particularly CGMS XXI), CGMS Members considered it important to continue to review such definition of formats. However, CGMS should not create its own standard nor should CGMS adopt a particular standard that may not be adopted outside CGMS. It was noted that transcription of the Meteosat archive possibly offers an opportunity for a pathfinder exercise between Members. The WG-II Members agreed to continue to discuss this and the entire archiving standard issue at the next CGMS.

During the discussion the WMO requested that EUMETSAT provide the requirements used to derive the MTP system.

ACTION WG II.7 EUMETSAT to make available relevant requirement documentation used to develop the Meteosat Archive and Retrieval Facility.

PRC WP-06 provided information on the archiving of FY-2 image data. The format used is close to that which is used by GMS.

WORKING GROUP III : GLOBAL CONTINGENCY PLANNING

III/1 Approval of the Terms of Reference

In EUM WP-17, EUMETSAT presented a revised draft Terms of Reference for the CGMS Working Group on Technical Measures for Global Contingency Planning.

The Working Group unanimously recommended the Terms of Reference to the Plenary session for adoption.

Participants agreed that the Working Group would meet during full sessions of the CGMS, although separate meetings may also be convened as necessary.

III/2 Review of Actions from CGMS XXI

EUMETSAT presented a review of actions from CGMS XXI and reported on recent developments in global contingency planning. Actions 21.28 through 21.31 had been completed, with the satellite operators and WMO to continue work on Action 21.32 (see section III/4).

III/3 Bent Pipe Operations with GMS, GOES, or Meteosat

EUMETSAT and NOAA informed the group of the two agencies' 1993 signature of a Long-Term Mutual Backup Agreement, which formalized the long-term contingency plans for their geostationary meteorological satellite coverage. The plan will come into effect upon both agencies' establishment of their baseline satellite configurations. This baseline should be established after GOES-J's successful launch and check-out, which should be completed by autumn 1995. Satellite operators and the WMO welcomed this agreement as an important step toward more comprehensive global contingency planning efforts.

III/4 Global Contingency Planning Approach

EUMETSAT discussed recent efforts to develop a comprehensive technical strategy to expand existing contingency plans. Japan stated that while the MTSAT program may restrict its ability to participate in a long-term contingency plan, it would be possible to develop a medium-term contingency planning and a technical approach which could be formalized in the event of an urgent need for back-up support. All satellite operators therefore agreed to formulate a CGMS technical strategy which could include Japan or other satellite operators in a three-way approach. The Working Group recommended to the Plenary that a general technical strategy be developed within the CGMS context, and that Working Group III begin an initial outline. Pending Plenary approval, EUMETSAT agreed to coordinate a dialogue on this issue, with the aim of developing an outline for a CGMS technical strategy. A completed version would be provided by Working Group III for consideration by the Plenary at CGMS XXIII. This technical strategy could be regularly reviewed and incorporated into the next publication of the CGMS

Consolidated Report. The strategy could also be provided to WMO for incorporation into the Guide and Manual for the Global Observing System (see discussion under Agenda Item D.2.)

ACTION WG III.1 EUMETSAT to continue to coordinate the dialogue with Japan and the USA in order to develop an approach for a medium- and long-term global contingency strategy compatible with the plans and constraints of all satellite operators. The first draft of this strategy will be completed and forwarded to CGMS participants for comments by 30 October 1994.

ACTION WG III.2 CGMS members to review and comment on this draft global contingency strategy in advance of CGMS XXIII.

FINAL PLENARY SESSION

J. SENIOR OFFICIALS MEETING

J.1 Appointment of Chairman of final session

The CGMS XXII Senior Officials meeting was convened at 10 a.m. on 15 April 1994. Dr. Larry Heacock was confirmed as the Chairman of this session.

J.2 Reports from the Working Groups

The reports of Working Groups were presented by their Chairman: Mr. R. Wolf (WG I. on Telecommunications), Mr. C. Staton (WG II on Satellite Products), and Dr. D. Hinsman (WG III on Global Contingency Planning).

The Senior Officials took note of the reports and the Chairman thanked participants for their active and fruitful discussions. They endorsed the proposed actions with minor modifications, and considered the recommendations formulated.

Noting the conclusion of the Working Group I, the plenary discussed the proposal to create an ad hoc CGMS Working Group on Data Collection Systems. It was agreed that technical issues related to the expansion of the IDCS should be dealt by WG I in the future, while policy aspects shall be relevant to Item F of the Plenary Session.

Noting the conclusions of the Working Group II, CGMS endorsed the recommendation that periodic Meteosat and GOES cross-calibrations should be implemented operationally in real time, and agreed to give the corresponding Action to NOAA and EUMETSAT. CGMS then decided to establish a Winds Working Group under the recommended Terms of Reference, to be found in Annex to this Final Report. It was noted that the work plan and procedures of this Working Group would be discussed at its first meeting, to take place at or before the next CGMS Plenary Meeting. The CGMS also welcomed the recommendation from ITWG.

The CGMS endorsed recommendation to establish a Working Group on Technical Measures for Global Contingency Planning.

J.3 Nomination of CGMS Representatives at WMO and other meetings

The Senior Officials proposed that Dr. Paul Menzel should represent CGMS at the next meeting of the ITWG, MM. Morgan and Lafeuille would represent CGMS at the WMO EC in June 1994, and Mr. Morgan at the WMO Congress. Dr. Szejwach would represent CGMS at the WMO/CBS WG-Sat, and at the Wind Workshop. Mr. Wolf would represent CGMS interests at the SFCG. The Secretariat would represent CGMS at CEOS.

J.4 Any Other Business

The CGMS congratulated the USA and the Secretariat for their efforts in arranging this plenary

session, and expressed their warm thanks to the U.S. Naval Academy for the outstanding support provided in hosting this meeting.

J.5 Approval of Draft Final Report

The plenary session, with all Senior Officials present, reviewed the draft Final Report of the meeting. Noting a few modifications and the new Actions, resulting from the Working Groups, the Senior Officials approved the Report. The Secretariat agreed to include all the amendments into a revised draft which would be distributed to CGMS Members for final comment prior to publication.

J.6 Summary List of Actions from CGMS-XXII

Permanent Action 10 : All CGMS Members to monitor the IDCS allocation list and report any discrepancies to the Secretariat.

ACTION 22.01 WMO to distribute to all WMO Members a copy of the LRIT specification document to be provided by EUMETSAT.

ACTION 22.02 Russian Federation to forward for distribution by WMO, to appropriate WMO Members, the data dissemination schemes, frequency plan and transmission characteristics of the GOMS/Elektro Satellite, after its launch and in-orbit commissioning.

ACTION 22.03 The Secretariat to update as necessary, and forward to WMO a list of current and planned geostationary and polar satellites for distribution in the WWW Monthly Newsletter.

ACTION 22.04 CGMS Members to review the comprehensive description of the space-based portion of the global observing system, as given in Annex I of the Final Report of the Executive Council Panel of Experts on Satellites. CGMS Members to comment by 14 July 1994 if it formed a necessary and sufficient description of WMO contingency requirements.

ACTION 22.05 EUMETSAT to consider the possibility of moving a "spare" Meteosat satellite, if necessary, in order to provide coverage over the Indian Ocean.

ACTION 22.06 NOAA and WMO to investigate the possibility of making Special Sensor Microwave Imager (SSM/I) data and products available on the GTS, so that they could be received by all NWP centres, tropical cyclone RSMCs and regional forecast offices.

ACTION 22.07 WMO to investigate mechanisms for having WMO Members place satellite image interpretation messages for all polar-orbiting satellites on the GTS.

- ACTION 22-08** CGMS Members to provide WMO, by September 1994, with comments on Appendix A of WMO-WP-07, related to the Requirements for Small Ground Stations.
- ACTION 22-09** WMO to be included in the list of addressees informed about DCP non-conformant operations.
- ACTION 22-10** USA/NOAA to distribute by 1 July the definition of the LRPT format.
- ACTION 22-11** CGMS Members are requested to notify the Secretariat of their agreement on the proposed LRPT format by 1 December 1994.
- ACTION 22-12** WMO to articulate its operational requirements for the global exchange of satellite image data, to consider how best to achieve such exchange and to make recommendations as appropriate to CGMS.
- ACTION 22-13** USA to provide the Russian Federation with existing application notes on the use of soil wetness index derived from SSM/I.
- ACTION 22-14** WMO and NOAA to collaborate on the development of a plan concerning volcano ash satellite monitoring, for submission to WMO/CBS for review and eventual implementation.
- ACTION 22.15** All CGMS Members to forward to EUMETSAT a list of topics to be included in a CGMS Directory of Meteorological Applications, by 1 July 1994.
- ACTION 22.16** EUMETSAT to collect the suggestions of all Members, to draw up on this basis a global outline of a CGMS Directory referring to a target audience and to propose a procedure to implement this project.
- ACTION 22.17** CGMS Members to review the updated list of experts in satellite applications and provide to WMO the names of additional experts.
- ACTION 22.18** CGMS Members to investigate possibilities to co-sponsor Specialized Satellite Training Centres and report to CGMS-XXIII.
- ACTION 22.19** Satellite operators to provide to the WMO information on users, ground stations, and frequency use, preferably in a database format, by 30 May 1994.
- ACTION 22.20** CGMS Participants to provide to the WMO by 15 May 1994 the names and Omnet or Internet addresses of staff interested in a CGMS. FREQUENCY message forwarding capability.
- ACTION 22.21** WMO to develop a CGMS.FREQUENCY message forwarding capability for interested CGMS participants prior to 30 May 1994.

- ACTION 22.22** EUMETSAT and NOAA to consider the operational implementation of periodic Meteosat and GOES cross calibrations in real time, and report to CGMS XXIII.
- ACTION 22.23** EUMETSAT and NOAA to investigate the use of polar orbiters to normalize geostationary satellite calibration and report to CGMS XXIII.
- ACTION 22.24** CGMS Members to forward to Japan and to the Secretariat their comments on GMS visible reflectance monitoring.
- ACTION 22.25** NOAA/EUMETSAT to respond, to the extent possible, to PRC's requests for calibration assistance.
- ACTION 22.26** CGMS Members to identify Core Representatives to the Winds Working Group by October 1, 1994.
- ACTION 22.27** NOAA will provide documentation to interested parties on the 3-channel technique of precipitable water derivation, following establishment of GOES I useful performance.
- ACTION 22.28** CGMS Members to provide comments on the proposed NOAA K,L,M 1b format direct to NOAA by August 1, 1994.
- ACTION 22.29** EUMETSAT to make available the relevant requirement documentation used to develop the Meteosat Archive and Retrieval Facility.
- ACTION 22.30** EUMETSAT to continue to coordinate the dialogue with Japan and the USA in order to develop an approach for a medium- and long-term global contingency strategy compatible with the plans and constraints of all satellite operators. The first draft of this strategy will be completed and forwarded to CGMS participants for comments by 30 October 1994.
- ACTION 22.31** CGMS Members to review and comment on this draft global contingency strategy in advance of CGMS XXIII.

J.7 Date and Place of Next Meetings

CGMS was pleased to accept an offer by EUMETSAT to host CGMS XXIII in Darmstadt in late May 1995.

CGMS also welcomed a proposal from WMO to host the CGMS XXIV in Switzerland.

**CGMS XXII PLENARY MEETING
ANNAPOLIS, USA, 11-15 APRIL 1994**

AGENDA

A. PRELIMINARIES

- A.1 Introduction
- A.2 Election of Chairman
- A.3 Arrangements for the Drafting Committee
- A.4 Adoption of Agenda and Work plan of W/G Sessions
- A.5 Review of Action Items from Previous CGMS Meetings

B. REPORT ON THE STATUS OF CURRENT SATELLITE SYSTEMS

- B.1 Polar Orbiting Meteorological Satellite Systems
- B.2 Geostationary Meteorological Satellite Systems

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 Inter-regional planning
- D.2 Global planning, including orbital positions

E. METEOROLOGICAL SATELLITES AS PART OF WMO PROGRAMS

- 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 via Satellite
- G.2 Dissemination via GTS or other means

H. OTHER ITEMS OF MORE GENERAL INTEREST

- H.1 CEOS Global Satellite Observation and Information Network
- H.2 Applications of Meteorological Satellite Data for Environment Monitoring
- H.3 Search and Rescue (S&R)
- H.4 Anomalies from Solar and Other Events
- H.5 Directory of applications
- H.6 Other items of interest

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

WORKING GROUP I - TELECOMMUNICATIONS

- I/1 Coordination of Frequency Allocations
- I/2 Results of SFCG - Secretariat Report
- I/3 Electronic Bulletin Boards (EBB)
- I/4 Preparation of WG Report

WORKING GROUP II - SATELLITE PRODUCTS

- II/1 Image processing techniques
- II/2 Satellite Data Calibration
- II/3 Wind Vectors
- II/4 Vertical sounding
- II/5 Other Parameter Extraction
- II/6 New Products & their use in Numerical Weather Prediction
- II/7 Coordination of Code forms for satellite Data
- II/8 Coordination of Data Formats for the Archive and Retrieval of Satellite Data
- II/9 Preparation of WG Report

WORKING GROUP III - GLOBAL CONTINGENCY PLANNING

- III/1 Approval of the Terms of Reference
- III/2 Review of Actions from the CGMS XXI
- III/3 Bent Pipe Operations with GMS, GOES or Meteosat
- III/4 Global contingency planning approach
- III/5 Preparation of WG Report

----- 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 Approval of Draft Final Report
- J.6 Summary List of Actions from CGMS XXII
- J.7 Date and Place of Next Meetings

WORKING PAPERS SUBMITTED TO CGMS-XXII

(Summary titles - agenda item in brackets)

ESA

- ESA-WP-01 Improvement to the Operational Calibration of Meteosat-3 at 75° W (II/2)
- ESA-WP-02 A New Resampling Method for METEOSAT Image Rectification (II/1)
- ESA-WP-03 A Transputer Augmented Workstation for Fast External Satellite Data Processing (FESIP) (II/1)
- ESA-WP-04 The METEOSAT-6 (MOP-3) Anomaly (B.2)
- ESA-WP-05 Improved Operational Water Vapour Calibration (II/2)
- ESA-WP-06 Upper Tropospheric Humidity Observations from Meteosat and Comparisons with ECMWF Forecasts (II/6)
- ESA-WP-07 An Overview on Applications and Capabilities in the Meteosat Image Processing System (II/1)
- ESA-WP-08 Enhanced Upper Tropospheric Humidity Product (II/6)
- ESA-WP-09 The XADC Mission (B.2)
- ESA-WP-10 Meteosat Spacecraft Anomalies (B.2)
- ESA-WP-11 Water Vapour Wind Vectors (II/3)
- ESA-WP-12 Double CD-ROM "TERRA" (H.6)

EUMETSAT

- EUM-WP-01 Review of action items from CGSM-XXI (A.5)
- EUM-WP-02 Status of the Meteosat Operational and XADC programmes (B.2)
- EUM-WP-03 Status of EUMETSAT Polar System (C.1)
- EUM-WP-04 Status of Meteosat Transition Programme (+ Annex on the Meteorological Product Extraction Facility) (C.2)
- EUM-WP-05 Status of the Meteosat Second Generation programme (C.2)
- EUM-WP-06 Status and problems of the IDCS (F.1)
- EUM-WP-07 Status of the Meteorological Data Distribution mission (G.1)

EUM-WP-08	Status of the implementation of image data encryption (G.1)
EUM-WP-09	Protection of passive sensors (I.1)
EUM-WP-10	Report from SFCG (I.2)
EUM-WP-11	Report from the EUMETSAT-JMA-NOAA-WMO Wind Workshop (II.3)
EUM-WP-12	Cloud Motion Winds verification statistics (II.3)
EUM-WP-13	Modification to the verification procedure of Cloud Motion Winds (II.3)
EUM-WP-14	Progress with the ATOVS development (II.4)
EUM-WP-15	EUMETSAT approach of research activities (+ Annex on assimilation of ERS-1 Scatterometer data) (II.6)
EUM-WP-16	The MTP Archive and Retrieval Facility and the approach of formats (II.8)
EUM-WP-17	Review of the draft Terms of Reference of the Working Group for Global Contingency planning (III.1)
EUM-WP-18	Global contingency planning approach: status report (III.4)
EUM-WP-19	List of publications available from EUMETSAT (H.6)
EUM-WP-20	Proposal for the establishment of a CGMS Working Group on Satellite Winds (II.3)
EUM-WP-21	Report on the 2nd Data Collection System Users Conference in Athens (F.4)
EUM-WP-22	Report on the 6th European AVHRR Data Users Meeting in Belgirate (H.6)
EUM-WP-23	Cost elements for a CGMS Directory of Satellite Applications (H.5)
EUM-WP-24	EUMETSAT comments on the WMO satellite data requirements (E.1)

JAPAN

JAPAN-WP-01	Review of action items from previous CGMS Meetings (A.5)
JAPAN-WP-02	Status of Geostationary Meteorological Satellite-4 (GMS-4) (B.2)

- JAPAN-WP-03 Present status of the Geostationary Meteorological Satellites (B.2)
- JAPAN-WP-04 Future Geostationary Meteorological Satellite System (C.2)
- JAPAN-WP-05 Support to WCRP (E.2)
- JAPAN-WP-06 Status and Problems of IDCS (F.1)
- JAPAN-WP-07 Interference monitoring of IDCS channels (F.1)
- JAPAN-WP-08 Status of ship IDCPS including ASAP (F.2)
- JAPAN-WP-09 Status of the ASDAR (F.3)
- JAPAN-WP-10 Dissemination of DCP Messages (F.4)
- JAPAN-WP-11 Stretched VISSR of GMS-5 (G.1)
- JAPAN-WP-12 New Computer System at Meteorological Satellite Center, JMA (II.1)
- JAPAN-WP-13 Plans for GMS-5 Products (II.5)
- JAPAN-WP-14 Monitoring of GMS Visible Image Data (II/2)
- JAPAN-WP-15 Status Report of TOVS Processing System in Meteorological Satellite Center (II.4)
- JAPAN-WP-16 Current Status of GMS Wind Derivation (II.3)
- JAPAN-WP-17 The Current Stage of Development of Water Vapour Wind Extraction Method (II.3)

PEOPLES REPUBLIC OF CHINA

- PRC-WP-01 The progress of FY-1 C, D (C.1)
- PRC-WP-02 The progress of FY-2 System (C.2)
- PRC-WP-03 On the Proposed International Conference on Satellite Meteorology in Asia-West Pacific Region (H.6)
- PRC-WP-04 The Coordination between FY-2 and GOMS Data Collection Platform Frequency (F.1)
- PRC-WP-05 The Plan on Establishing Radiometric Calibration Fields (II.2)
- PRC-WP-06 Archiving of FY-2 Image Data (II.8)

PRC-WP-07 On the Monitoring of Philippine Volcano Eruption (H.2)

RUSSIA

- RUS-WP-01 Polar Orbiting meteorological Satellite System (METEOR 2, 3) (B.1)
- RUS-WP-02 Geostationary Meteorological Satellite System (GOMS N 1) (B.2)
- RUS-WP-03 Future Polar Orbiting Meteorological Satellite System (METEOR-3M) (C.1)
- RUS-WP-04 Future Geostationary Meteorological Satellite System (GOMS N2) (C.2)
- RUS-WP-05 Processing of RAW GOMS Data and Preparation of Low Resolution Imagery for WEFAX Dissemination (G.1)
- RUS-WP-06 On Potential Re-Allocation of Meteorological Satellite Service Frequency Bands (I/1)
- RUS-WP-07 The Current Stage of Development of the Operational Calibration Scheme for GOMS IR Window Channel (II/2)
- RUS-WP-08 Cloud Motion Wind Extraction from GOMS Data (II/3)
- RUS-WP-09 Derivation of Sea Surface Temperature and Precipitable Water Over Sea from METEOR and NOAA Measurements (II/5)
- RUS-WP-10 The Production and Meteorological Application of Remote Sensing Data with high Spatial Resolution (II/5)
- RUS-WP-11 Development of TOVS processing Software in the Hydrometeorological Center of Russia (II/4)
- RUS-WP-12 Cloud Parameters and Precipitation Intensity (II/5)

USA

- USA-WP-01 Polar Orbiting Meteorological Satellite Systems (B.1)
- USA-WP-02 Geostationary Operational Environmental Satellite-7 (GOES-7) (B.2)
- USA-WP-03 GOES-I Program Status (B.2)
- USA-WP-04 GOES-Next Series (C.2)
- USA-WP-05 Recommendations Concerning the International Data

USA-WP-06	Collection System (IDCS) (F.1) Ships including ASAP (F.2)
USA-WP-07	ASDAR Update (F.3)
USA-WP-08	Dissemination of DCP Messages (GTS or other means) (F.4)
USA-WP-09	CEOS Global Observation Satellite and Information Networks (H.1)
USA-WP-10	Applications of the DMSP SSM/I Derived Soil Wetness Index in Environmental Monitoring (H.2)
USA-WP-11	Update on the International COSPAS-SARSAT Program (H.3)
USA-WP-12	The COSPAS/SARSAT Task Group Structure: System Assessment, 406 MHz Beacon Matters, and Geostationary Satellite Systems (H.3)
USA-WP-13	Summary of the 1993 World Radio Conference (I.1)
USA-WP-14	International Procedures for Satellite Coordination (I.1)
USA-WP-15	NOAA's Electronic Bulletin Board (I.3)
USA-WP-16	Advanced Very High Resolution Radiometer (AVHRR) Pathfinder Calibration Activity (II.2)
USA-WP-17	Intercomparison of the Operational Calibration of GOES-7 and METEOSAT-3/4 (II.2)
USA-WP-18	Remote Sensing of Severe Weather (II.5)
USA-WP-19	New GOES and POES Sounding and Winds Products (II.6)
USA-WP-20	Committee on Earth Observation Satellite (CEOS) (II.7)
USA-WP-21	Proposed Formats of Level 1B Data Sets for NOAA-K, L, and M (II.7)
USA-WP-22	Recommendation to Create an Ad Hoc CGMS Working Group on Data Collection Systems (F.4)
USA-WP-23	Status of NOAA Polar-Orbiting Operational Environmental Satellites (B.1)
USA-WP-24	Status of NOAA Geostationary Operational Environmental Satellites (POES) (B.2)
USA-WP-25	Low Resolution Picture Transmission (G.1)

USA-WP-26	NOAAPORT Broadcast System (G.1)
USA-WP-27	NOAA Mosaic Home Page (I/3)
USA-WP-28	Satellite Implementation Plan for Post-GOES-I Launch (B.2)
USA-WP-29	NOAA Comments on WMO Satellite Data Requirements (E.1)
USA-WP-30	U.S. Volcano Detection and Alerting Efforts (H.2)
USA-WP-31	Satellite Support to the Global Ocean Observing System (H.2)
USA-WP-32	International TOVS Working Group Report to CGMS (II/4)
USA-WP-33	Status Report on the NOAA-J and the NOAA-K, L, M Satellite Series (C.1)
USA-WP-34	Status of CGMS Action Items (A.5)

WMO

WMO-WP-01	Tropical Cyclone Programme Requirements (E.1)
WMO-WP-02	Review of Action Items from Previous CGMS Meetings (A.5)
WMO-WP-03	WMO Global Contingency Requirements (D.2, III/2)
WMO-WP-04	Status of WMO Satellite Data Requirements (E.1)
WMO-WP-05	OWSE-Africa (E.1)
WMO-WP-06	WMO Strategy for Education and Training in Satellite Matters (H.6)
WMO-WP-07	Status of CBS Working Group on Satellites Sub-Group on Small Groundstations (E.2)
WMO-WP-08	Draft Project Plan for Low-Cost Low-Resolution Satellite Receiver (E.2)
WMO-WP-09	List of WMO Publications (H.6)
WMO-WP-10	Overview of WMO's Activities in Relation to the Use of Satellites for Operational Hydrology (E.2)
WMO-WP-11	ASDAR and ASAP (F.2)
WMO-WP-12	Radio Frequency Allocation (I/1)

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TERMS OF REFERENCE OF THE CGMS WORKING GROUP ON CLOUD MOTION WINDS

1. BACKGROUND

The Working Group on Cloud Motion Winds (WG-CMW) was established as a permanent Working Group at the 22nd meeting of the Coordination Group for Meteorological Satellites (CGMS) in Annapolis, Md, USA, 11-15 April 1994. The WG-CMW was established to pursue an objective of CGMS which is to encourage complementarity and compatibility in meteorological data products and to complement the work of other international satellite coordination mechanisms. A long time task of CGMS has been the routine exchange of validation statistics of routine inter-comparisons of Cloud Motion Vectors from the Geostationary satellites. CGMS has also encouraged an increase of scientific research in this field. This WG is established to place greater emphasis on the coordination of operational and research efforts in the derivation of Cloud Motion Winds.

2. PURPOSE

This Working Group on Cloud Motion Winds (WG-CMW) is established to continue and emphasize the CGMS accomplishments and objectives in the area of operational extraction of Cloud Motion Winds from satellite data. This emphasis includes the coordination of complementary and compatible operational procedures, the development of common verification and validation procedures, and the encouragement of a robust program of scientific research in this technology.

3. OBJECTIVES

- A. To devise and implement regular procedures for the exchange of data on inter-comparisons of operational CMW.
- B. To promote harmonization and, where feasible/practical, the standardization of operational procedures for deriving CMW.
- C. To establish agreement for standards in the verification and validation of CMW derived from satellite data. This includes the :
 - selection of data sources for validation
 - standardization of statistical parameters to be used for verification and inter-comparison.

- standardization of verification criteria, i.e. standard windows in space and time for collocations and standard criteria for the acceptance (or consideration) of the validation data.
- D. To promote increased scientific activity in this field, and to establish routine means of exchanging scientific results and progress.
- E. To establish and encourage a regular dialogue and information exchange with the users of the data. This to include both scientific and operational exchanges in order to:
- agree on the designation of data quality as a part of the delivery of the data (e.g. quality flags),
 - agree on modifications to data formats and codes, and
 - discuss means of verifying the usefulness and quality of the data for numerical analysis and prediction.

4. MEMBERSHIP

The Working Group shall be comprised of representatives nominated by the satellite operators of the CGMS or by other members of the CGMS. The CGMS or the WG-CMW may invite experts from the user community to participate in the activities of the group. The CGMS should consider a balance of producers of the CMWs and scientists working in the field for membership in the Working Group.

5. WORKING ARRANGEMENTS

The Working Group will meet on an ad-hoc basis, but at least once a year to review progress in the field. The CGMS can request a meeting at any time. The Chair of the Working Group is appointed by a plenary of the CGMS, and serves at the pleasure of the plenary. The Chair shall report activities of the committee at the scheduled plenary meetings of the CGMS. The members of the WG-CMW are to forward their contributions to the WG Chair in time for the annual report by the chair to the CGMS plenary.

The WG-CMW will organize Workshops, co-sponsored by CGMS members. The Workshops are to promote the exchange of scientific and operational information between the producers of CMW, the research community, and the user community. The Workshops may be held every two years, or as required by the judgement of the WG Chair.

TERMS OF REFERENCE OF THE WORKING GROUP ON TECHNICAL MEASURES FOR GLOBAL CONTINGENCY PLANNING

A CGMS Working Group on Technical Measures for Global Contingency Planning is established, to pursue the goal of ensuring continuity of operational meteorological satellite data and services on a global scale in the event of contingency situation affecting the baseline coverage plan.

The CGMS Working Group on Technical Measures for Global Contingency Planning will be convened on the occasion of full meetings of CGMS and supplemented as far as necessary by correspondence and ad-hoc meetings, in order :

- To review, on a continuing basis, the user requirements for continuity of satellite data and services including those as specified by the WMO,
- To develop, and update as appropriate, a global contingency plan which could be expected to satisfy the agreed user requirements, taking into account individual and/or regional plans,
- To develop the necessary arrangements, both technical and legal, to implement the global contingency plan, when necessary, taking into account short, medium and long-term needs,
- To formulate recommendations in order to improve the compatibility between satellites , so as to ease contingency plans.

The CGMS Working Group on Technical Measures for Global Contingency Planning will report the progress of their deliberations and efforts to Plenary sessions of CGMS.

CGMS MEMBERS' SATELLITES IN GEOSTATIONARY ORBIT

Status, April 1994

Operator	Satellite	Launched	Location	Status
EUMET-SAT	Meteosat 3	06/1988	75° W	Operational Replac. GOES
	Meteosat 4	03/1989	0°	Back-up to Meteosat 5
	Meteosat 5	03/1991	0°	Operational
	Meteosat 6	11/1993	0°	In commissioning
	Meteosat 7 (MTP)	---	0°	Projected launch 1996/1997
	MSG 1	---	0°	Projected launch 2000
	MSG 2	---	0°	Projected launch 2002
	MSG 3	---	0°	Projected launch 2006
INDIA	INSAT I-d	06/1990	83° E	Domestic operational use
	INSAT II-a	07/1992	74° E	Domestic partly operational use
	INSAT II-b	07/1993	93.5° E	Domestic operational use
	INSAT II-e	---	TBD	Projected launch 1997/98
JAPAN	GMS-3	08/1984	120° E	Back-up of GMS-4
	GMS-4	09/1989	140° E	Operational
	GMS-5	---	140° E	Projected launch in early 1995
	(MTSAT-1)	---	140° E	Projected launch in 1999
USA	GOES - 7	02/1987	111.7° W	Operational
	GOES - 8	04/1994	90° W	In commissioning
	GOES - J	---		Projected launch in 1995
	GOES - K	---		Projected launch in 1999
	GOES - L	---		Projected launch in 2000
	GOES - M	---		Projected launch in 2004
RUSSIA	Elektro-1	---	76° E	Projected launch in 1994
	Elektro-2	---	76° E	Projected launch in 1997
CHINA	FY-2	---	105° E	Launch date TBD

CGMS MEMBER'S SATELLITES IN POLAR ORBIT

Status, April 1994

Operator	Satellite	Launched	Orbit	Status
EUMET-SAT	Metop-1	---	AM 827 km	Projected launch in 2000
	Metop-2	---	AM 827 km	Projected launch in 2005
USA	NOAA-11	09/1988	PM 850 km	Operational
	NOAA-12	05/1991	AM 850 km	Operational
	NOAA-J	---	PM 850 km	Projected launch 08/1994
	NOAA-K	---	AM 850 km	Projected launch 08/1995
	NOAA-L	---	PM 850 km	Projected launch 08/1997
	NOAA-M	---	AM 850 km	Projected launch 08/1998
	NOAA-N	---	PM 850 km	Projected launch 08/2000
	NOAA-N'	---	PM 850 km	Projected launch 08/2003
	NOAA-O	---	PM 824 km	Projected launch 08/2005
	NOAA-P	---	PM 824 km	Projected launch 08/2008
	NOAA-Q	---	PM 824 km	Projected launch 08/2011
CHINA	FY-1 C	---	870 km	Projected launch late 1990's
	FY-1 D	---	870 km	Projected launch late 1990's
RUSSIA	Meteor 2-21	08/1993	950 km	Operational
	Meteor 3-5	1991	1200 km	Operational
	Meteor 3-7	01/1994	1200 km	Operational
	Meteor 3-8	----	1200 km	Projected launch in 1995
	Meteor 3M-1	----	925 km	Projected launch in 1997
	Meteor 3M-2	----	925 km	Projected launch in 1998
	Meteor 3M-3	----	925 km	Projected launch in 1999

CGMS XXII FINAL REPORT

Appendix A :

SELECTED PAPERS SUBMITTED TO CGMS XXII

An Overview on Applications and Capabilities in the METEOSAT Image Processing System

Frank - J. Diekmann

Abstract

Since the launch of its first pre-operational model, the METEOSAT system has evolved to one of the most well-known earth observation satellite projects. In particular through its imagery mission it has become an indispensable tool for a large user community. Both the quality of the images produced by METEOSAT satellites and their processing onground have been continuously improved in recent years. This paper is a short review of the present capabilities and applications of the METEOSAT image processing at the European Space Operations Centre (ESOC, Darmstadt). It will start with a brief overview on available hardware tools for real-time and offline processing of METEOSAT images. Geometrical image restoration and radiometric quality control are the main tasks in this area. But in addition a number of dedicated (software) tools and test set-ups had to be developed for special testing of the satellite performance, for instance during the commissioning of a new spacecraft. Finally, a short summary on current studies and new developments related to the METEOSAT imagery mission concludes this review.

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25 January 1994

1. Introduction

Since the launch of the first METEOSAT satellite MET-1 in 1977, the whole METEOSAT system has undergone a multitude of changes and upgrades and evolved from a single spacecraft irregularly providing images to a group of three satellites operated in parallel. MET-3, launched in 1988, is the last of the preoperational series (MET-1 reached its end of life in 1979, MET-2 was de-orbited in December 1991) and serves at 75°W for the Extended Atlantic Data Coverage (XADC) mission (de Waard, 1993). MET-4 and MET-5 belong to the operational series (Mason, 1987). MET-4 supports the various missions at 0° and MET-5 is used as standby satellite at 10°W. MET-6 has been launched end of November 1993 and will probably later become the new mission satellite.

An enormous wealth of data has been provided by the METEOSAT satellites, with the image data being the dominant source of information. These images are acquired and transmitted in three spectral channels on an half hourly basis. This makes per satellite and per day up to 1.8 Gbyte of image information. Two of such data streams - three, if the backup facilities are used - are currently received, processed, disseminated and archived at ESOC (European Space Operations Centre) in Darmstadt, Germany.

Since the start of the METEOSAT project, the understanding of the image contents, the quality of the processed images and the deduced products have significantly improved (Diekmann and Amans, 1990). Necessary prerequisites were regular upgrades of the computer technology available at ESOC as well as the development of dedicated software tools. The latter were often based on a variety of special tests, studies and the unavoidable treatment of spacecraft anomalies. Experiences and findings gained from the daily dealing with the satellites and their products resulted in a better understanding of the spacecraft characteristics and lead to technical modifications on the following flight models. As a result the user community could be provided faster with more reliable and geometrically more stable and accurate satellite images. Meteorological products determined at ESOC also profit from this development which is for instance reflected in the high quality of the cloud motion winds (Woick, 1990; Schmetz et al., 1993).

This paper is an attempt to summarize tools and developments of the present METEOSAT image processing system and the resulting know-how existing at ESOC in processing of remotely sensed data. Some tools for geometrical restoration and radiometric quality control are briefly explained. An overview on special tests and current studies as well as a short glance at the possible applicability to other projects concludes this paper.

2. METEOSAT image data processing at ESOC

In the field of Earth observations, sampled images are the results of a convolution of a scene and various point spread functions (e.g. of the atmosphere, the optics, the sampling aperture). It is therefore evident that the measured or observed image is different from the true image as a result of the interaction of the sensor and the true image signal. In addition to such radiometric degradations, acquired images in Earth observation projects are geometrically distorted by deviations of spacecraft parameters from their nominal values, such as orbit, attitude, spin, sampling rate, etc.

Main purpose of the onground processing of images from the operational METEOSAT satellites is the identification and correction of these effects in real time. The four METEOSAT images transmitted once every 30 minutes are received in three spectral channels (infrared window, water vapour absorption band, two images in the visible spectral region), consist of 8 bits per pixel (6 bits for WV and VIS channels of the preoperational series) and contain 2500*2500 pixels per image (2500*5000 for each of the VIS channels). Two of these data streams are currently processed in parallel at ESOC and a third one is possible for limited time periods (e.g. commissioning, anomaly investigations, etc.). Preprocessing of the continuous raw image data stream, which consists predominantly of demultiplexing the data, is performed on a Siemens R30 computer, the so-called Front End Processor (FEP). The same computer type is used for telecommand and telemetry handling, dissemination of the processed data and as interface for image display stations (DPO). The bulk of the image data processing tasks is running operational on one of the two mainframe (MF) computers (COMPAREX 8/98). The second MF serves as backup and is normally used for other purposes. These machines have undergone regular upgrades in order to cope with the growing need for computing power. Starting with about 2 Mips in 1981, the MF computing power increased from 5 Mips in 1988 to more than 20 Mips in 1991 and has currently a capacity of nearly 50 Mips.

After transmission the images are demultiplexed to form continuous pictures. A variety of restoration steps are then possible, which normally, however, just remain an attempt to reconstruct the (unknown) true image. In the METEOSAT image processing only a geometric restoration is performed (rectification). A deconvolution of the acquired images in order to compensate for radiometric degradations is presently not applied, since it is a time consuming task and it affects the image pixel counts in an irreversible, so far not known manner. However, a study is planned, aiming at the development of a possible deconvolution filter and its impact on the image quality, which would be applicable with the nowadays available computer resources. Further, the impact of different noise sources on the image quality are studied and their magnitudes in all images estimated.

SUN workstations and PC hosted image processing tools are available for offline studies and tests. A transputer augmented workstation (TAW) with a total of 23 processors distributed over four different modules serves as a powerful state-of-the-art development and study environment (see also Fig.4). The capacity of this workstation is highlighted by the processing power of one of the modules for real time image data resampling (3 Transputers, 2 Intel processors), which reaches a theoretical floating point performance of 160 Mflops (Zobl and Scheiber, 1992). Processed images are finally disseminated through the satellite, received by a Primary Data User Station (PDUS) and stored on a VAX computer. This system is equipped with a dedicated image processing system for fast inspection of the final image formats supplied to the user community.

The main areas of METEOSAT image processing are summarized in Fig.1. It includes the most important tasks and processes as well as some tools, facilities and methods. The different parts of the diagram will be explained in more detail in the following chapters.

3. Geometrical image restoration

Images acquired from METEOSAT, processed and disseminated are used by a wide research community as a mean to gain a better understanding of atmospheric processes. This, however, depends largely on the radiometric quality and geometric stability of the image data. The latter is achieved by a data correction process called image rectification. Images transmitted from the satellite are distorted due to its various movements during the image taking process. Since this prevents an accurate geographical identification of an image pixel, an evaluation of the image distortions and a following resampling of the image pixels is a way of reducing these geometric errors.

The METEOSAT raw image rectification is performed since a few years in real-time (Bos et al., 1990) and consists of three main steps. First, a number of varying parameters of the imaging systems needs to be determined. They can be partly predicted, because most of the disturbing forces affecting the spacecraft parameters are of periodic nature, and are partly derived from real-time measurements. Based on these parameters, the deformations on a series of grid points are calculated using a mathematical model initially developed by Wolff (1985). Finally, the raw image pixels are resampled according to the resulting deformation matrix to form the rectified image. The presently used resampling method is the so-called nearest neighbour resampling. The implementa-

tion of this method is fast and cheap, but it causes a residual statistical error, which results in a degradation of the absolute accuracy of the data points, as well as their relative stability (Diekmann and de Waard, 1992).

The method used to assess the rectification accuracy of METEOSAT images is described in detail by Adamson et al. (1988). The complex system called "Quality Control of Image Rectification" (QCIR) is based on about 120 reference landmarks (coastlines, islands, lakes) spread over the scanned Earth disk. They are extracted from rectified IR and VIS images and filtered by a simple automatic histogram and peak-identification process to extract those landmarks with less than 10% cloudiness. These landmarks are later subject of another automatic test (based on landmark specific correlation coefficients) to delete the remaining cloud contaminated landmarks collected during about one week. The cloudfree landmarks passing both tests are correlated with an accurate reference landmark data set. The landmark displacement is defined to be the displacement of the maximum of the correlation surface from nominal. Results for each landmark are presented in terms of line and pixel deviations as well as in absolute and relative rms errors of the sum of both. This process runs on a weekly basis. For the relative errors the landmark position is compared with the results of the previous slot, which gives an indication of the rectification stability.

Constant biases determined with this method are usually attributed to a set of registration parameters describing the positions of the detectors onboard the satellite with respect to the detector optical axis. These important parameters are usually updated during the commissioning of a spacecraft and later optimized, if necessary.

Another essential parameter serving as an input for the deformation model is the position of the south polar Earth horizon (the space-atmosphere transition defined at a specific pixel count) in the IR channel. The corresponding temperature actually reflects a vertical atmosphere column integral and is as such the mean of this layer at the Earth's limb. A warming or cooling of the stratosphere consequently means a change of the determined horizon positions which in return degrades the rectification accuracy. This effect is observed during the normal seasonal temperature changes, which allowed a modelling of this phenomenon, but also after a strong warming due to volcanic dust reaching the south polar stratosphere (Diekmann and Bowen, 1992).

Fig.2 summarizes the performance of the METEOSAT image rectification system since 1989. Large rms errors during the commissioning of MET-4 in 1989 were caused by imperfect detector registration values which could be corrected during the following weeks. The seasonal wave in the rectification errors can still be identified in 1990; a correction scheme based on a model of this

oscillation was implemented in early 1991, resulting in a clear improvement of the quality. Volcanic dust in the lower stratosphere after the Pinatubo eruption in 1991 caused a warming of the east image horizons (July and August) and later of the antarctic stratosphere. The resulting rectification degradations could be reduced by simple parametrizations of these temperature changes in the rectification software. The remaining errors (around 0.6 IR elements rms) are predominantly inherent in the nearest neighbour resampling.

In addition to these rather predictable features, the rectification software had regularly to be extended in order to cope with unexpected anomalies originating from the spacecraft. For instance, the "fish" problem of MET-4 (electronic disturbances in all image channels, Baratelli et al., 1990), and the rotating lens of MET-5 (Olivier, 1991) had serious impacts on the radiometric and geometric image quality. Special software tools had to be developed to minimize the resulting geometrical distortions in the images (Hanson and Adamson, 1992).

4. Radiometric quality control

The true image signal sensed by the METEOSAT radiometer is altered and degraded by the different distortion factors mentioned earlier, by various noise sources originating from the satellite and the transmission, by the sampling and digitization process, and also through the introduction of spatial shift errors (during the attempt to geometrically correct the images). Usually the images are disseminated to the users without any radiometric changes (exception : the removal of "fishes" for MET-4).

Indirectly however, the detector response function is taken into account during the conversion of radiometric counts into radiances in order to obtain physical information within the MIEC processing (Meteorological Information Extraction Centre). For the longwave channels the relation between radiances (R) and temperatures (T) is given by the integral over the product of the wavelength dependent Planck function $B(\lambda, T)$ and the detector spectral response function $\Phi(\lambda)$.

$$R(T) = \int_{\lambda_1}^{\lambda_2} B(\lambda, T) \Phi(\lambda) d\lambda$$

This is then directly proportional to the image count via the MIEC calibration coefficient (ESA STR-224, 1987).

4.1. Monitoring facilities

Besides the image calibration, a variety of further image processing techniques are applied in the MIEC processing aiming at the calculation of a number of meteorological products from segmented rectified images. Among these methods are segment processing (segment statistics), pattern recognition and classification (clouds), windowing techniques and others. Manual product quality control stands at the end of the product derivation process, before the physical data are supplied to the meteorological community. An image display system is connected to a R30 computer which gets the images directly from the MIEC processing chain on the mainframe. It provides a variety of image display functions on a 512*512 pixel screen. A dedicated software system allows in addition an interactive manual change of remaining deficiencies in the meteorological products. More details on this topic can for instance be found in ESA STR-224 (1987).

Additional monitoring devices serve as indispensable tools for performance and quality controlling at the various stages of the image processing chain. Ten monitors connected to the front end processors display different raw image channels of the two operational satellites before any data processing. Auxiliary information coming with the imagery data are the basic input for a radiometer monitoring tool (AUXVIEW) which consists of three parts. The first is an auxiliary data graphical display for advanced monitoring of the contents of the radiometer AUX data. On the same workstation an expert system is installed which analyses radiometer anomalies and proposes recovery procedures (MERADEXP). These functions are combined with a reduced image display (RID) of the image currently being taken.

Besides the already mentioned DPO systems, a transputer augmented workstation (TAW) is available for fast monitoring and processing of raw and rectified images. They are transferred in real time via an FDDI interface from the mainframe computer, reduced to simple byte maps and stored on harddisks, which are each equipped with a dedicated transputer for fast I/O processing (see Fig.4). This allows very fast and parallel zooming, scrolling and loops of up to 250 images in full resolution. Additional functions are pixel inspections, window extraction and grey value statistics, classifications, overlays, Fourier transformations and many others.

The processed images are retransmitted to the users via the satellite in two forms. These disseminated high resolution digital (HR) and analog (non-calibrated data, WEFAX) image formats are also received at ESOC with PDUS and SDUS systems (Primary and Secondary Data Users Stations). The receiving stations are connected with a μ VAX and a VAX station, respectively, which offer a variety of standard image processing tools.

4.2. Operational Quality Assessment

A variety of parameters is determined during the operational image processing for assessing the radiometric quality of the METEOSAT images. The main reason is that the analog signals measured by the radiometer in three spectral bands, controlled, formatted and converted into 8 bit digital counts within the imaging electronics (SIC) before transmitted to ground, are affected by various noise sources (Diekmann and Amans, 1990). This noise can be divided into three components : digitization-, Gaussian- and periodic noise. The digitization noise is the rounding error of the digitized signal, which represents the measured analogue radiance in discrete steps. Secondly, for a normal distributed analogue signal, the Gaussian error (i.e. the variance σ^2) can be calculated from the space corner information. The maximum signal (minus the space offset) divided by a combination of both numbers yields a signal to noise measure, which characterizes the performance of the different onboard electronics, the effects of gain changes and sensor contaminations as well as the degradations due to radiometric anomalies. Based on the above mentioned MIEC calibration, the noise in the longwave channels can be transformed to physically meaningful measures (NE Δ T). Bit error statistics are also obtained from the space corner counts. The ratio of even and odd image counts is an indication of the degree of non-linearity of the A/D converter onboard the spacecrafts.

Periodic noise components are monitored by applying an FFT algorithm to the image lines. The discrete Fourier transforms are derived from the transforms of every 50th raw (unprocessed) image line. It is given as a function of frequency in cycles per image line. Besides inspection of amplitude and frequency of clear noise peaks, some additional parameters are calculated characterizing the mean spectrum. Fig.3 is a typical example of the final power spectrum densities of a WV image.

The entropy E determines the average information content or, equivalently, the amount of detail of an image. It also represents the minimum number of bits (b) necessary to represent a pixel in the image or alternatively the available redundancy r ($r = b - E$). The entropy may be calculated on the basis of actual image data with the image histogram.

$$E = - \sum_{k=0}^{255} p(k) \cdot \log_2(p(k))$$

Because of the correlation between grey values, another estimate for the entropy is based on the probability distribution of the count differences of consecutive pixels.

Slot-, daily and weekly averages of these and other parameters are regularly controlled and summarized in quarterly reports. This way, the performance of the satellite instruments and particularly any degradations can be followed up and - if necessary and possible - corrective actions be initiated.

5. Special purpose testing

5.1. Commissioning

The purpose of the commissioning phase following the launch of a satellite is to verify the nominal performance of the METEOSAT missions. Therefore, during this phase, it has to be established that the performance of the spacecraft and of the ground facilities are adequate to carry out the missions in a reliable way. This means for the imagery mission that not only the operational parameters are checked for different onboard configurations, but also a variety of special tests are performed for assessing the system margins of the instruments. Dedicated software tools had to be defined, prepared and tested (first with simulated imagery data), before they could be applied to actual data transmitted from the satellite immediately after its start of operations.

Among these special tests are images taken with no or maximum signals. In the first case only an empty space segment is scanned such that the various noise sources can be studied without being "disturbed" by real Earth image data. In the latter case the radiometer is pointed towards the sun. Images scanned this way are disturbed by various reflections/emissions (flares, stripes, halos, etc.) and unwanted DC restore effects, which normally affect real images around eclipse periods. The assessment of interchannel crosstalk is another commissioning exercise. Only one channel is switched on at a time. The effect of this channel on all the others could be determined by receiving and evaluating the electronic signals produced by the onboard imaging electronics.

The radiometer moves from -9° to $+9^\circ$ around the horizontal plane in order to scan 2500 lines. Stopping the instrument at well defined positions allows to assess the stability of various spacecraft parameters. The earth image line which is repeatedly scanned this way appears as a vertical block in the image. Assessment of the left and right borders - or "horizons" - enables the validation of the spin rate stability and the raw image line start jitter. Short thruster pulses induce an oscillation of the horizons. Frequency and duration of this jitter characterizes the performance of the onboard nutation damping.

An unexpected behaviour of a spacecraft during the commissioning (e.g. rotating lens of MOP-2, different quality of the two redundant onboard electronics, etc.) always means ad hoc definitions of tests and the preparation of special software tools in order to understand the observed behaviour and - if possible - to initiate corrective actions.

5.2. Special investigations

The different stages a METEOSAT satellite passes throughout its lifetime allows a variety of special tests directed towards the assessment of both its own performance and of the onground processing. The basic restriction is always, however, that the ongoing operations are not interrupted (except for immediate anomaly investigations).

The same way the commissioning tests characterize the start of operations, a series of end-of-life (EOL) tests precedes the final re-orbiting manoeuvre of a spacecraft. MET-2 was the only spacecraft used for such tests so far, which were not possible - or allowed - during the normal day-to-day operations. An example is the change of the onboard focusing device. This part of the optical system is not supposed to be operated during normal operations and therefore the image focusing setting is the one established prior to launch. A verification of this assumption was part of the

MET-2 EOL tests in November 1991, when the moon as a relatively stable image source (no atmosphere) was repeatedly imaged with varying positions of the focus of the telescope. These miniscans were evaluated using dedicated software tools with the intention to describe the sharpness of the moon image in the three spectral bands. A useful parameter was found to be the noise power density (NPD) being the integral over all discrete frequencies of the power spectrum of the miniscans higher than a certain threshold. This parameter indicated highest variability (maximum sharpness) of the data for all channels when the focusing was slightly off the normal position.

At the end of its lifetime, MET-2 had reached a high inclination orbit ($> 4^\circ$) and was positioned around 10°W . This offered furthermore a good opportunity to validate and improve the rectification software to cope with such unusual conditions.

Several tools are available at the moment to assess the quality of the image rectification. A temporary spot check was made possible by the so-called Laser Landmark Experiment, which is presently ongoing. An ionised argon laser was used as a continuous wave transmitter, with a power

of up to 20 W, in an attempt to hit MET-4 and to produce in this way a weak signal in the visible images during nighttime. For the few successful slots acquired until today, it was possible to confirm the reliable performance of the rectification by collocating the received signal in the image with the exactly known geographical position of the laser (Grasse, France). In a possible later case, with stronger and clearer signals in the images, we hope to be able to determine the point spread function of the instrument from the received count distribution.

During the lifetime of a METEOSAT satellite, various events regularly degrade the quality of the received images, among which the eclipses and the detector contamination periods are the most frequent. The eclipse causes a strong increase in spin speed, strong disturbances of the sun in the images and DC restore effects in the slots around the actual eclipse. These effects have to be studied for each spacecraft. The same sort of spacecraft characteristic behaviour is observed during detector contamination periods, when the sensitivities of the longwave sensors are reduced and need to be amplified by increasing the onboard gains (Mason and Diekmann, 1990). An example of periodic noise frequencies for MET-4 observed during autumn 1990 is given in Fig.3. The peaks in the power spectrum belong to two onboard frequencies, of which one (256 cycles/line, 10.4 kHz, from telemetry clock, strongest appearance in IR channel) is only observed after amplifying detector signals during a contamination phase. This effect normally disappears after a decontamination exercise. The second noise source originates from onboard converters (66 and 33 kHz) and affects mainly the WV channels of the preoperational satellites. A Wiener filter has been designed to remove the resulting stripes in the WV images, which was, however, not used operationally.

6. Studies and new developments

Since the beginning of the METEOSAT image data processing the nearest neighbour resampling technique was used within the geometrical correction scheme (see §3). In recent years the determination of the image deformation was significantly improved such that the rectification errors averaged over an image approached the theoretical statistical limit, which is of course only reached in the case of absence of external perturbations as for instance eclipses or unpredictable events affecting the image. In order to further improve the rectification quality, another resampling algorithm was needed to replace the nearest neighbour scheme. A variety of methods were possible, all based on interpolation of weighted pixel counts surrounding the pixel in question. Radiometric changes introduced in this way may cause a slight increase in errors (smoothing, ringing, etc.), but perhaps also an improvement by reducing the impact of the satellite's radiometer on the original image (inverse filtering).

A necessary prerequisite for identifying an optimal filter is a precise understanding of the actual sampling of the satellite itself, which was the purpose of a study under ESA contract (Sidla, 1991). The sampling process modifies the real - actually unknown - image information to an unknown degree. Overlapping of pixels causes redundancy, gaps between image lines on the other hand results in loss of information. In addition, the incoming radiation is of course modified by the optical system of the radiometer and folded with the sensor's spectral response. The resulting analog signal is then converted into 8 bit digital data. Moreover, the sampled image is distorted by the various spacecraft parameters (sensor misregistration, attitude, orbit, spin speed, ...). Besides these functions, the radiometer model developed under this contract simulates the radiometric and geometric noise sources. As such it is a suitable means to study the relation of errors produced by the instrument and the sampling process on one hand and the resampling errors on the other. The main components of the model are :

- * scanning and mapping of a spatially high resolution input image,
- * telescope optics and IR sensor,
- * amplifier and filters (anti-aliasing),
- * Sample-and-Hold and ADC (A/D Converter),
- * various noise sources (gaussian, periodic, crosstalk, A/D converter nonlinearities)

With a model of the METEOSAT image sampling process as a prerequisite, another study was initiated to identify an optimal technique for satellite data resampling (Ulm and Buchroithner, 1992). For the assessment of possible resampling candidates a number of tests characterizing their performance had to be developed. These tests were then applied to fourteen resampling methods which were found in the literature and partly provided with modified parameters. The most promising candidates (best behaviour on smooth areas and edges) were the bicubic spline function with $\alpha = -0.5$, a linear combination of B-splines and the nonlinear Akima interpolation. The corresponding algorithms were implemented in the radiometer model and used together with nearest neighbour as reference method for resampling of deformed test images. All three methods show significantly improved results compared with nearest neighbour after initial tests. With further tests it is expected to confirm these results and to relate resampling induced grey value modifications with sampling and instrument noise. The bicubic spline (parametric convolutional) filter is currently tested under operational conditions. First results show an improvement of the relative (slot-by-slot) rectification accuracy by almost a factor three (rms errors reduced from about 0.6 to ca. 0.2 IR pixels).

The technical realization of these very time consuming resampling algorithms was part of a contract for a transputer augmented workstation (TAW) mentioned already above. The resulting FESIP (Fast External Satellite Image Processing) system is sketched in Fig 4. The scope of FESIP was a computer prototype in hard- and software for real time resampling using different interpolation techniques as described above, as well as rapid image display and processing. With the implemented applications the TAW achieves a performance of almost 200 Mflops (Scheiber, 1994). The design of the FESIP prototype supports interfaces to modules for further processing.

Besides the rectification module, a second component will be used for near real time data extraction. This module performs the calculation of water vapour wind vectors (WVWV) using an optimum pattern matching algorithm (as an example for data extraction). Various quality control tools are applied to the wind vectors, all with a minimum interaction with the present mainframe computer system. It offers in addition a variety of possibilities for testing, improving the operational system, future inclusion of IR winds, etc. Last but not least it provides wind vectors on a slot by slot basis.

Other state of the art techniques are currently applied in further METEOSAT studies. A neural network using an addressing network architecture is being developed for identification of high level clouds. The feasibility of different image data compression methods based on wavelets are subject of other research contracts. Another method has already been designed a few years ago, allowing error free compression and decompression (combined with a forward error correction code) of disseminated image formats in real time (MEANDER-1, Börger and Versteeg, 1991).

7. Outlook

This short overview on the various areas of image data processing within the METEOSAT environment at ESOC covers the most essential aspects and is certainly not complete or exhaustive. Both the hardware and software involved in this context emerged from many years of studies, developments and in-depths experiences with the METEOSAT system. Twelve years of almost continuous operations, of one to three satellites at a time, resulted in a wealth of information for online and subsequent processing, allowed the testing of state-of-the-art technologies and the immediate validation and application of new scientific concepts, particularly in the MIEC area (the Meteorological Information Extraction Centre).

Many tools used in the METEOSAT data processing environment are based on standard image processing techniques for remote sensing applications. As such they might be applicable for future satellite projects producing digital images as well. This refers to polar orbiting missions as ENVISAT or METOP (for instance in the areas of radiometric quality control, ground control points for geometric corrections, scene classifications and many others), but mainly for geostationary satellites as the next generation of METEOSAT spacecrafts (MSG). This project is currently in its definition phase and naturally profits from the experiences gained from the first series of satellites. For example, investigations of aliasing in METEOSAT images are supporting the definition of MSG anti-aliasing filter and detector shapes. Experiences with determining the detector co-registration during the onground processing form the basis for a possible later combined onboard and onground registration assessment design. Advanced resampling techniques studied for METEOSAT imagery data will definitely replace the currently used nearest neighbour approach in the near future. Many other applications are imaginable for future remote sensing projects. This way the present METEOSAT system could serve in other areas even beyond 1995, when the present operations of METEOSAT satellites will terminate at ESOC and be taken over by EUMETSAT.

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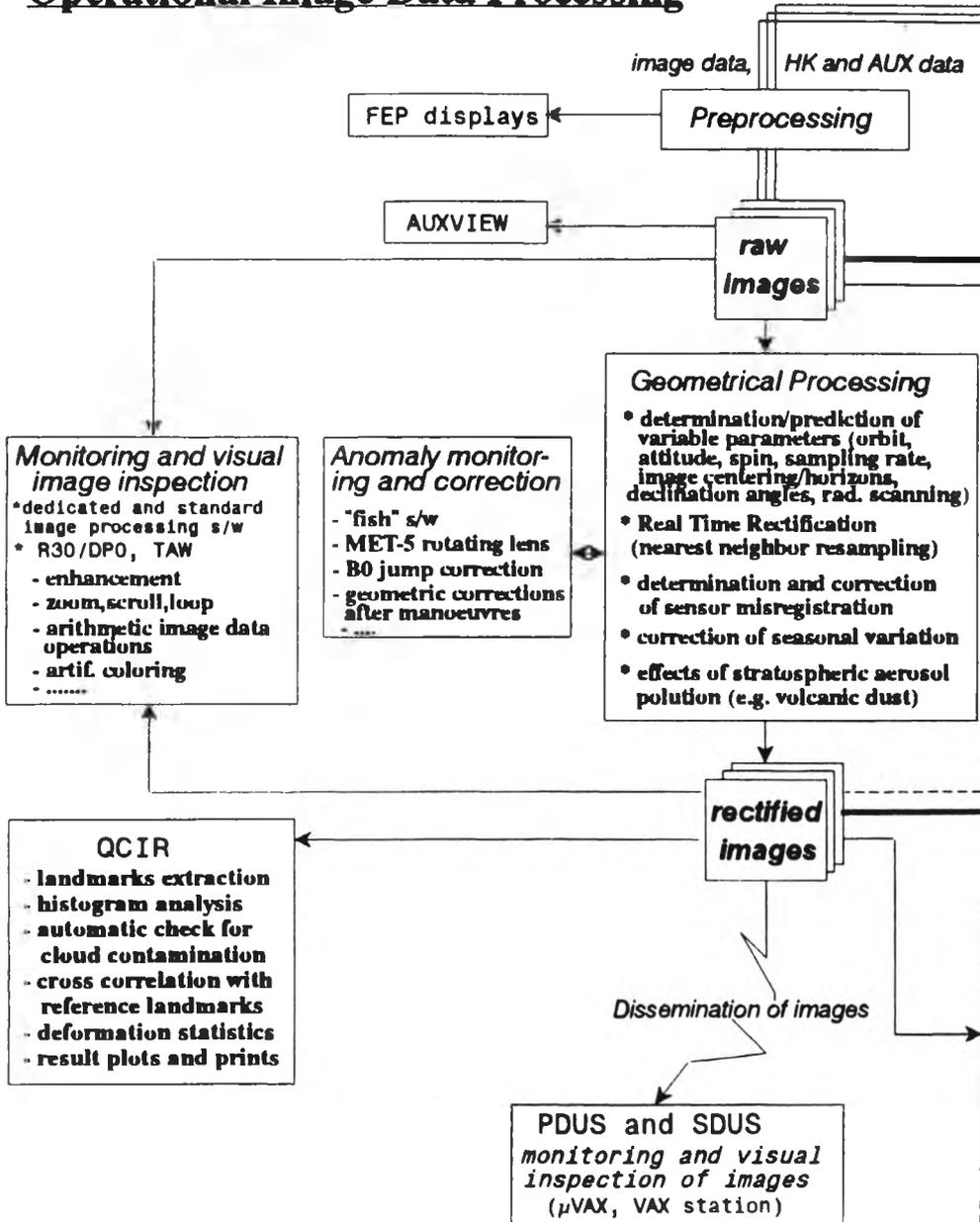
List of figures :

- Fig.1 :** Image processing areas in the METEOSAT system
- Fig.2 :** Development of the rectification accuracy since 1989
- Fig.3 :** Example of periodic noise in a MET-4 WV image with a contaminated sensor
- Fig.4 :** Workstation based image rectification and processing

Short title for running headline :

Overview on METEOSAT Image Processing

Operational Image Data Processing



A.20

Offline Activities

Special commissioning tests

- noise determination from space images
- sun interference tests
- crosstalk determination
- stopped radiometer tests (spin and attitude stability, line start jitter)

Special investigations

- moon scans for focussing/defocussing of s/c optics
- miniscans
- high inclination rectification
- Laser Landmark Experiment
- radiometric and geometric effects after eclipses
- noise measures before and after detector decontaminations
- WV noise removal s/w
- anomaly investigations

Studies

- new resampling techniques
- Radiometer modelling
- real time WV winds extraction
- automatic quality control of real time WV winds
- A/s rectification method tests
- Neural Network for cloud classification
- image data compression
 - wavelets,
 - MEANDER-1 plus FEC
- image data encryption
- real time dissemination

Archiving and hardcopy production

MF, VIZIR, PC, opt.disks

Radiometric processing

- grey value statistics, histograms (for Earth disk and space corners)
- gaussian noise parameters
- NEdT for IR and WV data
- bit error statistics
- entropy, 1st and 2nd order
- S/N ratios
- spectral domain parameters (power spectral densities, identification of noise frequencies, ..)
- ratios of even and odd counts (converter linearities)

Meteorological Information Extraction Center (MIEC)

** Operational processing*

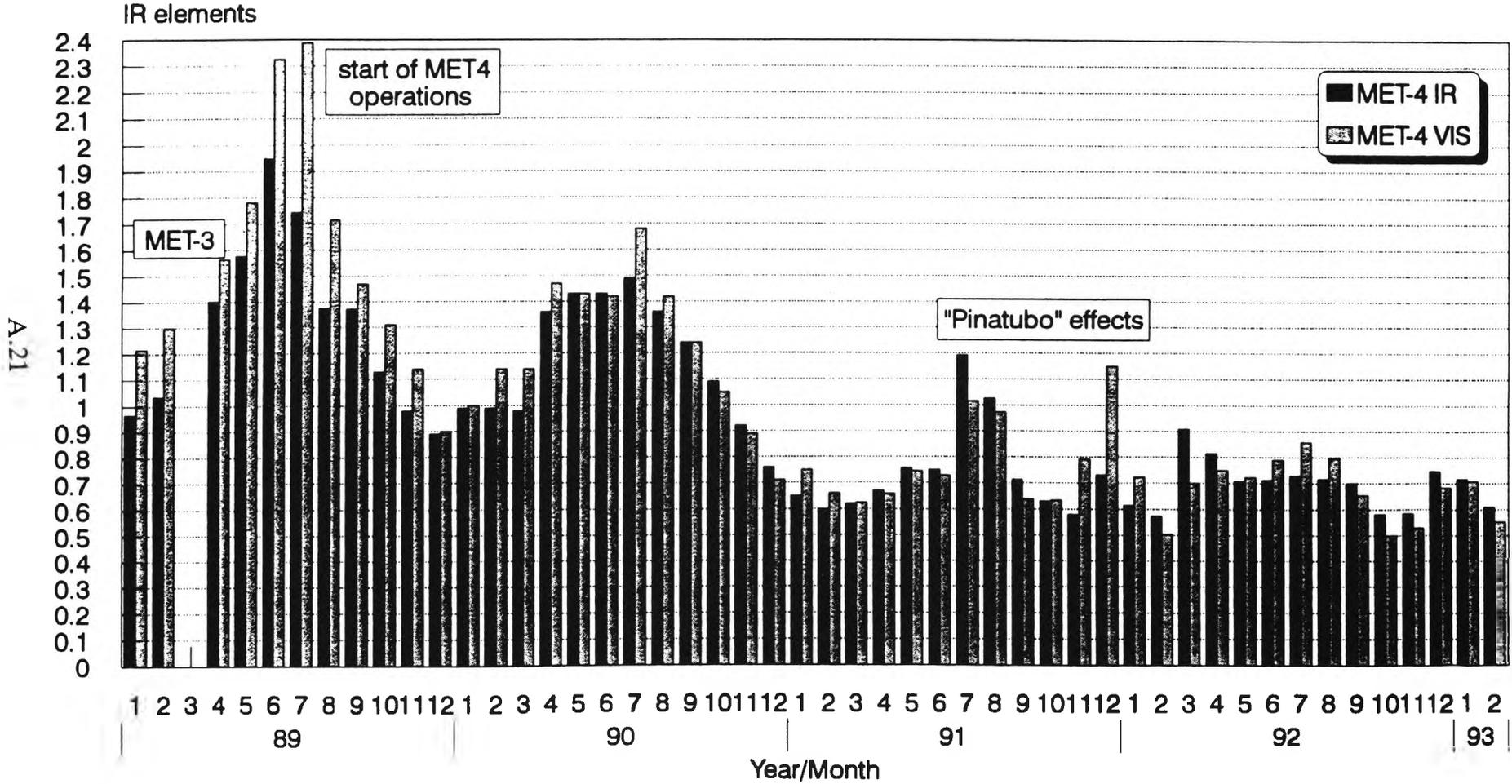
- image segmentation
- calibration
- product determination
- automatic quality control
- manual quality control

** Offline activities*

- product improvement
- generic research
- application of AVS image processing s/w

Rectification Accuracy

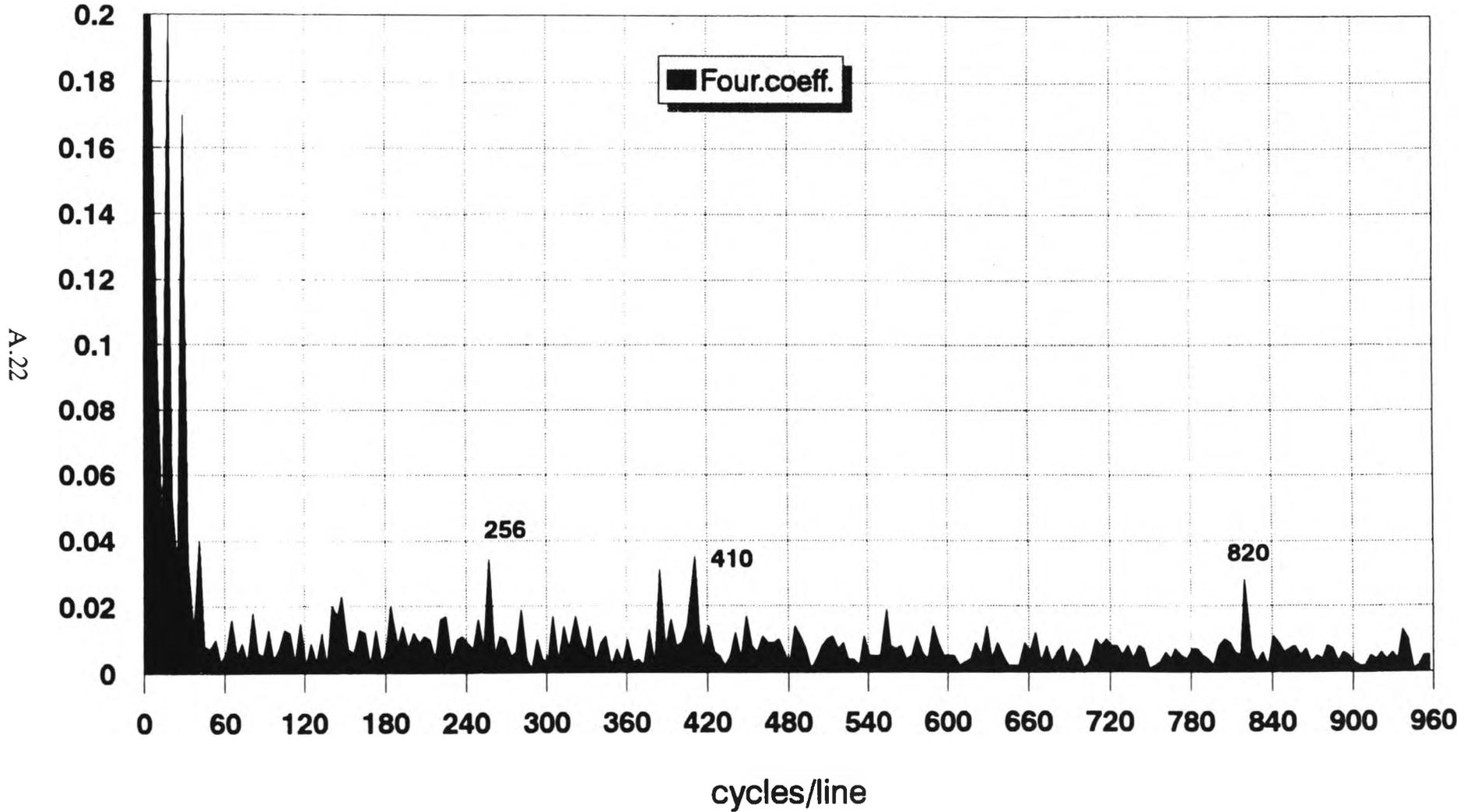
monthly averages of absolute rms errors
from MET-4 and MET-3 IR and VIS images



based on QCIR daily averages

Power Spectrum of WV channel

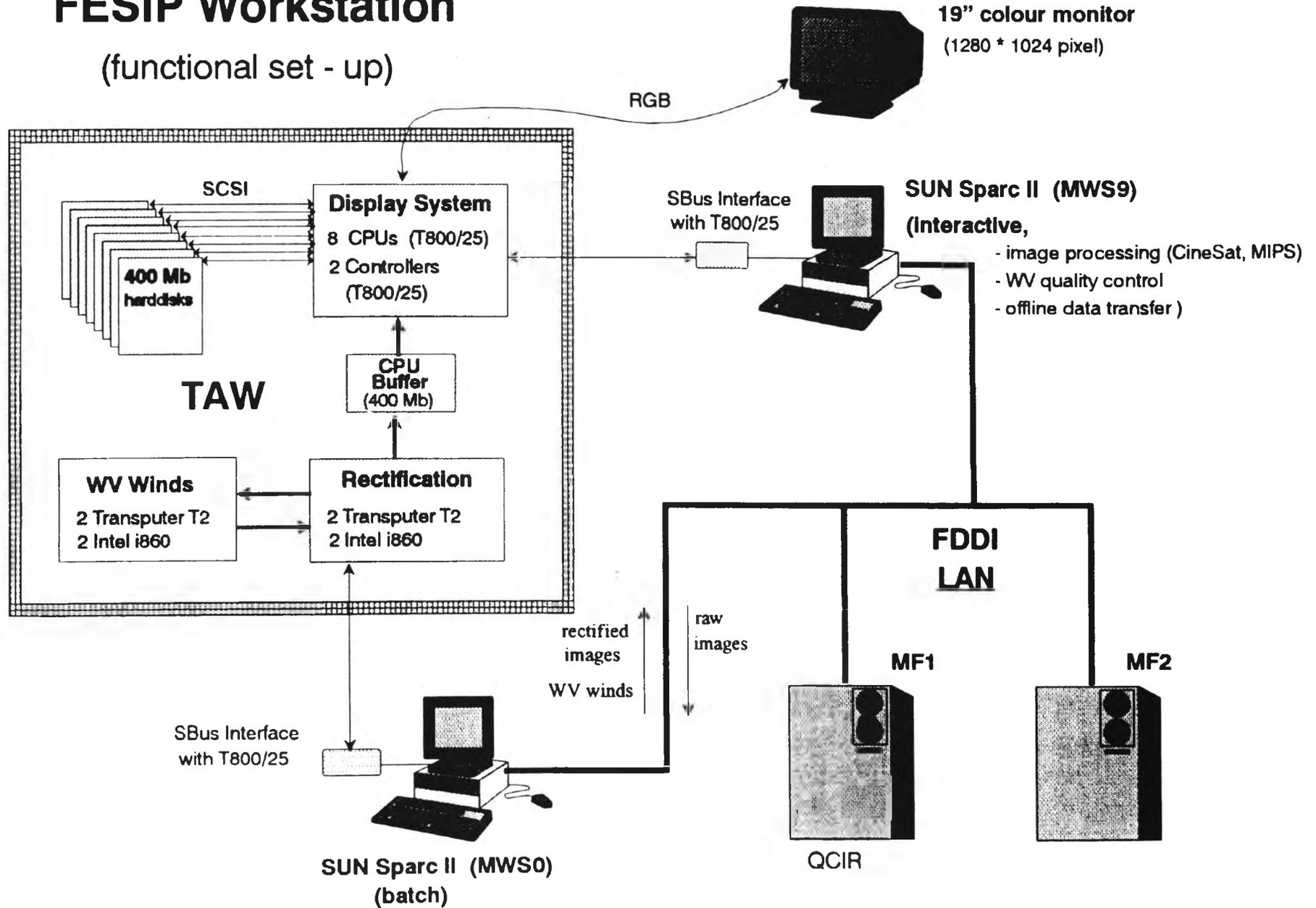
MET-4, 23/10/90, slot 32



based on 2048 pixels, averaged over 500 lines

FESIP Workstation

(functional set - up)



A.23

**The Meteorological Products Extraction Facility (MPEF)
in the new EUMETSAT Ground Segment**

I. Introduction

A new ground segment is being developed by EUMETSAT to take full control of all MOP and MTP Meteosat satellites from December 1995. The MTP ground segment includes a Mission Control Centre (MCC) and a Primary Ground Station. This will replace the system currently operated from the European Space Operations Centre (ESOC) in Darmstadt, Germany.

The MCC is located in a new EUMETSAT headquarters building in Darmstadt. The MCC is divided into four main facilities, each being developed by industry under direct contracts from EUMETSAT. The Core Facility is the

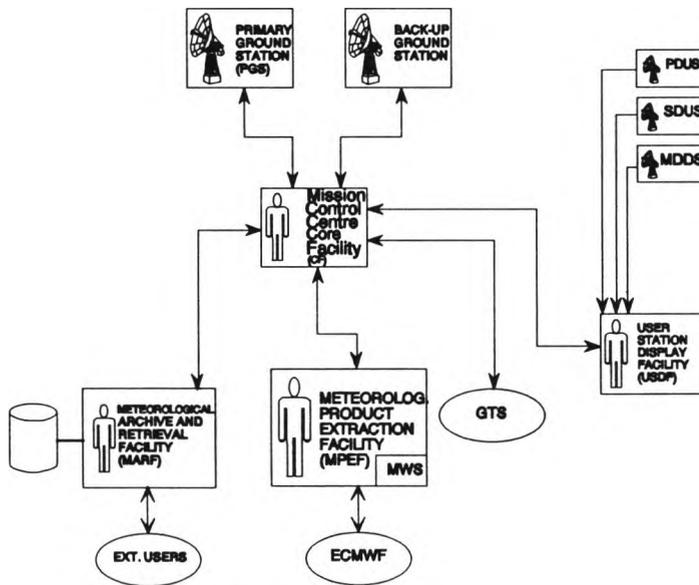


Figure 1 Position of the MPEF in the new EUMETSAT Ground Segment

central element of the MCC and includes the functions of mission management, satellite control, ground segment control and pre-processing of satellite data. The Meteorological Archive and Retrieval Facility (MARF) provides the capability for the users to access the historical data from Meteosat satellites. The User Station Display Facility (USDF) provides real-time visibility of the end products to operations staff within the MCC. The

MPEF completes the full data processing and produces a range of meteorological products for the end users. The overall ground segment architecture is shown in Figure 1.

In this paper some features of the MPEF are highlighted and its rôle in the EUMETSAT ground segment is described.

II. General Concept of the MPEF

The MTP MPEF is the successor to the current MOP MIEC. It features increased modularity and a number of improved processing and algorithms implementations.

The whole MTP ground segment is defined as a near real-time processing system in which the MPEF is embedded as a stand-alone facility. The MPEF will receive on a slot-by-slot basis pre-processed satellite data from the Core Facility, will process it to provide products and will return the products to the Core Facility for distribution. The near real-time derivation and distribution of the MPEF products will minimise the delay for product distribution and will reduce the processing load on the workstation based system. The system will, for instance, allow that the extracted products from a half hourly image slot will already be computed from the southern hemisphere when the Meteosat satellite is still scanning the northern part of the earth disk.

A standardised human-computer interface, based on OSF/Motif, has been developed and all operational rôles are available from the workstations by invoking the MPEF system menu. The following rôles have been defined in order to fulfil the operational requirements, i.e. Monitoring & Control, Scheduling, Analysis & Reporting, Database Preparation & Administration, Manual Quality Control, Visualisation & Analysis, System and Software Maintenance.

For Monitoring & Control and for Analysis & Reporting a parameterised approach has been defined. The use of system parameters will, for instance, allow the monitoring of hardware elements and the various stages of the application processing. Derived parameters will be used to calculate averages and means from the monitored data. Another set of parameters will be used for application and algorithm related analysis and will form the basis for the application reports.

III. MPEF Architecture

The MPEF will be implemented on a distributed workstation system comprising three processing chains for operational product extraction, commissioning and test support, and a separate development environment. One of the non-operational chains can be operated in hot-stand-by mode which will guarantee high availability of the operational system. The performance margin of 50% of all hardware elements and the possibility of re-

allocating processes will leave sufficient flexibility for future developments, improvements and the inclusion of new operational products. The use of off-the-shelf hardware will further improve the availability and will reduce maintenance costs. The MPEF architecture is depicted in Figure 2.

The MPEF network is based on an FDDI ring to which the workstations and servers are connected via Ethernet spurs. The interface to the Core Facility is via two redundant hardware devices.

Each processing chain consists of two HP 9000/735 workstations. The commissioning or the test chain will act as hot-standby, receiving the same data and doing the same processing as the operational system, but not distributing

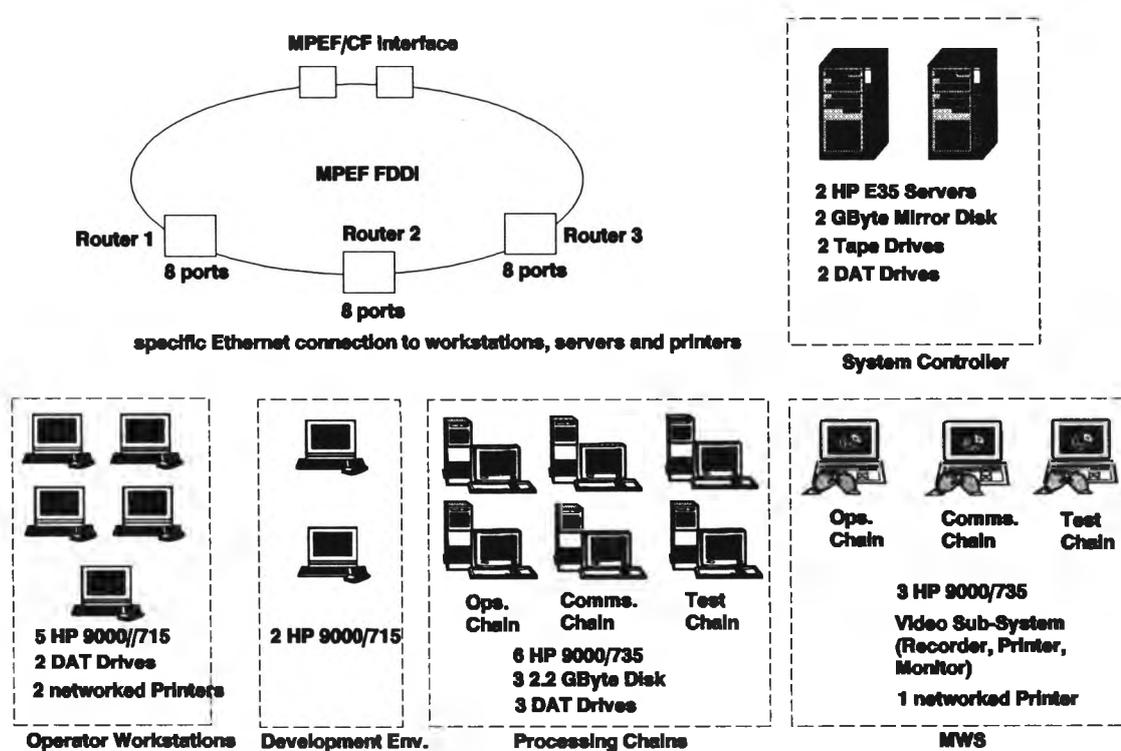


Figure 2 MPEF Hardware Architecture

the output data. In the event of a failure of the operational chain no manual intervention will be necessary to bring the stand-by to operational status.

The system controller consists of two redundant HP E35 servers connected to a dual ported, mirrored disk. There are three types of workstations in MPEF, namely the operator, the development and the MWS workstations. All workstations provide access to all operational rôles, although the manual quality control and the visualisation and analysis of MPEF products and images can only be performed from the MWS workstations. The prime function of the operator workstation is to facilitate monitoring and access to

the operator functions. The development workstations can be used for the development and testing of the new application and system software. The MWS Workstations are based on off-the-shelf software and guarantee a state-of-the-art graphics display and development facility.

IV. MPEF Product Processing

The algorithms are extensions of the MIEC algorithms and incorporate improvements in several areas. For instance, different cross correlation methods for the Cloud Motion Wind (CMW) product derivation will be implemented which include a Fast Fourier Transform (FFT) based method. It will be possible to select one method for each spectral channel. The product extraction and distribution frequency for a number of products has been increased and will, for instance, allow the distribution of the CMW product, derived from all three spectral channels (IR, WV and VIS) of the Meteosat satellite, every 1.5 hours.

The CLA and UTH product is available at 3 hourly intervals. The extraction of the CDS products in hourly intervals will allow the detailed analysis of daily variations of image data and parameters. Table 1 summarises the extracted MPEF products and their extraction frequency. The extraction times can be configured and the performance margin of the system will allow an increased extraction frequency in future if required by the end-users.

MPEF Product	Extraction Times (UTC)
Cloud Motion Wind (CMW)	0000, 0130, 0300, 0430, ..., 2100, 2230
Sea Surface Temperature (SST)	0000, 1200
Cloud Analysis (CLA)	0000, 0300, 0600, ..., 1800, 2100
Upper Tropospheric Humidity (UTH)	0000, 0300, 0600, ..., 1800, 2100
Cloud Top Height (CTH)	0300, 0900, 1500, 2100
Climate Data Set (CDS)	0000, 0100, 0200, 0300, ..., 2200, 2300
Precipitation Index (PI)	0000, 0300, 0600, ..., 2100
ISCCP Data Set (IDS)	0000, 0300, ... 2100 (for B1 and B2 data sets) AC data set according to coordinated schedule

Table 1: List of MPEF products and their daily extraction times

The new Automatic and Manual Quality Control concept will guarantee a flexible quality control and will allow the inclusion of quality control information in the individual products. With the introduction of the new BUFR code, instead of the currently used SATOB code, selected quality control information could be distributed with the product parameters to the end-user.

V. Conclusion

The MTP MPEF as the successor of the MOP MIEC features increased modularity and a number of new or improved processing and algorithms implementations.

The near real-time processing in the whole MTP ground segment will minimise the delay for product distribution. The MPEF architecture with three processing chains, including one hot-standby, and the use of off-the-shelf hardware guarantees high availability of the operational system. The possibility to reallocate application processes and a performance margin of at least 50% of all hardware elements will leave sufficient flexibility for future developments, improvements and the addition of new operational products.

The modular design of the algorithms software will reduce maintenance effort and allow future improvements in this area. The separate development environment and the test chain will provide the necessary facilities for research activities.

**PROTECTION OF PASSIVE SENSORS
USE OF 54.25 - 58.2 GHz FREQUENCY BAND**

1 PRESENT 54.25 - 58.2 GHz BAND ALLOCATION

The 54.25 - 58.2 GHz band is currently allocated to the following services on a primary basis:

- EARTH EXPLORATION-SATELLITE (passive),
- FIXED,
- INTER-SATELLITE,
- MOBILE,
- SPACE RESEARCH (passive).

No fixed or mobile services currently exist within this band. However, considerable pressure is building within Europe to introduce fixed services within this band. The introduction of mobile services is also under consideration. The existing allocation for this band, given above, allows for the introduction of such services.

**2 METEOROLOGICAL SATELLITE SERVICE UTILISATION OF
54.25 - 58.2 GHz BAND**

Since 1978, the Meteorological Satellite Service has used sections of the 54.25 - 58.2 GHz band for passive microwave sounding of the atmosphere. These measurements are provided by the Microwave Sounding Unit (MSU) instrument which is flown on the operational series of polar-orbiting weather satellites operated by NOAA. MSU is a 4 channel radiometer (see table 1 for channel characteristics) with two channels in the frequency band under discussion (at 54.76 - 55.16 GHz and 57.75 - 58.15 GHz). The microwave data are used in conjunction with data from infrared instruments to determine atmospheric temperature and humidity profiles. The microwave measurements are largely unaffected by cloud and therefore complement the infrared measurements (which cannot penetrate clouds) to provide an "all weather" sounding capability.

NOAA will upgrade the microwave sounding capability on its operational, polar-orbiting satellites in the next few years - starting with NOAA-K, which is currently scheduled for launch in 1995. This capability will be provided by two new instruments: the Advanced Microwave Sounding Unit - A (AMSU-A), for determining atmospheric temperature profiles, and the Advanced Microwave Sounding Unit - B (AMSU-B), for determining atmospheric water vapour profiles. Together, these two instruments have 20 microwave channels, of which 9 AMSU-A channels fall within the 54.25 - 58.2 GHz band. The channel characteristics of these instruments are given in tables 2 and 3 respectively.

The definition of the AMSU-A channels was based on experience gained with the MSU data, and AMSU-A can be considered as an evolution of the MSU

instrument (hence the name). AMSU-A determines the atmospheric temperature profile by measuring microwave radiation emitted by oxygen molecules in the frequency range 50 - 58 GHz. Figure 1 shows the atmospheric attenuation at microwave frequencies due to oxygen and water vapour together with the 20 AMSU channel positions.

At microwave frequencies, the determination of atmospheric temperature profiles is performed by making a series of radiometric measurements across an oxygen absorption line (or band of lines) at various atmospheric transmission values (i.e. from different height levels in the atmosphere). Only two such features exist in the O₂ microwave spectrum - a band at 60 GHz and a line at 118 GHz (see figure 1). Theoretically, either of these features could be used for temperature sounding. However, at 118 GHz the sensitivity is decreased by the increased water vapour attenuation and, more seriously, the measurements are significantly affected by the presence of clouds, thereby losing the important "all weather" sounding capability. The 60 GHz band should therefore be considered as a unique natural resource for which no practicable back-up exists and which must be protected.

The service provided by the MSU instrument is likely to continue through until the end of 1997. The first flight of the AMSU-A instrument, on NOAA-K, is currently scheduled for 1996. These services will be provided on an operational basis by NOAA from two separate, sun-synchronous, polar-orbiting satellites (with local equatorial crossing times around 07:30 and 13:30). In the longer timeframe (2000 onwards) Europe, through EUMETSAT and ESA, will assume responsibility for the "morning orbit" service. In the same timeframe, the microwave sounding capability will probably be upgraded by the addition of further channels in the frequency range 60.4 - 61.2 GHz. Such channels would increase the maximum height at which the atmospheric temperature is retrieved from approximately 45 km to approximately 70 km. This technique relies on a special interaction between the Earth's magnetic field and particular O₂ absorption lines (Zeeman splitting).

The introduction of Fixed (or Mobile) Services within the MSU or AMSU observing bands would cause interference to the passive sensors. As technologies develop and the passive sensors become more sensitive, the interference problems would increase. The Meteorological Satellite Service cannot accept to acquire corrupted sounding data over the regions concerned. Similarly, it seems unlikely that a commercial communications service could accept interruptions during a satellite overpass (up to 10 minute slots occurring approximately every 6 hours at roughly 01:30, 07:30, 13:30 and 19:30).

The experience that will be gained from the use of AMSU data and the continual improvement in technology, are likely to lead to some optimisation / changes in the observing channels in the future (e.g. alterations to centre frequencies or bandwidths, possible additional channels, etc.). Therefore, the Meteorological Satellite Service requests that the entire 54.25 - 58.2 GHz band be exclusively allocated to passive services. A restriction on emitters in the

frequency range 60.4 - 61.2 GHz is also requested. It is suggested that the Fixed and Mobile Services make maximum use of other parts of the frequency spectrum where they have primary allocations (e.g. 47.2 - 50.2, 50.4 - 51.4 and 59.0 - 64.0 GHz), and in particular above 61.2 GHz.

The allocation of frequency bands in the range 50 - 65 GHz to the Meteorological Satellite Service, and the use by the Meteorological Satellite Service of frequencies within this range are shown in figure 2.

3 RECOMMENDATIONS

The "all weather" sounding capability offered by the 60 GHz O₂ absorption band is a unique, natural resource for which no practicable back-up exists. The protection of this band for passive measurements is not requested for part-time scientific research, but rather for continuous, operational observations that are essential to the modern weather forecasting activities demanded by today's society.

This matter was discussed in the Space Frequency Coordination Group and actions were issued (to ESA, CNES, NOAA, EUMETSAT) to provide the necessary back-ground information which will allow to obtain the required protection within ITU. This includes the establishment of sharing criteria for the sensors.

Furthermore this subject was discussed within the WMO/CBS Working Group on Telecommunications. It was proposed to establish a working group to establish WMO inputs to ITU.

Some member states of EUMETSAT (France, UK) have produced documents on the protection of passive sensor frequencies and will forward those to their responsible national telecommunication frequency administration.

Although the agenda of the WARC in 1997 is not established it can be expected that this subject will be on the agenda for WARC 97 which will mainly be related to "Space Operations" activities.

It is proposed that CGMS expresses following recommendations:

- 1 Protection for the existing passive microwave sounding channels used by the Meteorological Satellite Service (MSU instrument) must be guaranteed.
- 2 Exclusive allocation for passive earth exploration and space research services is requested for the sensor frequencies wherever possible.
- 3 Additional exclusive allocation for passive observations is also requested for the band 60.4 - 61.2 GHz to accommodate the future upgrading of the Meteorological Satellite Service.

- 4 The existing and planned utilisation of the following bands, in which both Fixed and Mobile Services are assigned as primary users, should be investigated:

47.2 - 50.2 GHz,
 50.4 - 51.4 GHz,
 59.0 - 64.0 GHz.

Maximum use of these bands (while recognising point 3 above) should be made by Fixed and Mobile Services.

Table 1: MSU channel characteristics.

INSTRUMENT: Microwave Sounding Unit			
Channel	Frequency (GHz)	Bandwidth (MHz)	NE Δ T (K)
1	50.30	\pm 200	0.21
2	53.74	\pm 200	0.22
3	54.96	\pm 200	0.18
4	57.95	\pm 200	0.21

Table 2: AMSU-A channel characteristics.

INSTRUMENT: Advanced Microwave Sounding Unit - A			
Channel	Frequency (GHz)	Bandwidth (MHz)	NEAT (K)
1	23.8	± 135	0.3
2	31.4	± 90	0.3
3	50.3	± 90	0.4
4	52.8	± 200	0.25
5	53.596 ±0.115	± 85	0.25
6	54.4	± 200	0.25
7	54.94	± 200	0.25
8	55.5	± 165	0.25
9	57.290344	± 165	0.25
10	57.290344 ±0.217	± 39	0.4
11	57.290344 ±0.3222 ±0.048	± 18	0.4
12	57.290344 ±0.3222 ±0.022	± 8	0.6
13	57.290344 ±0.3222 ±0.010	± 4	0.8
14	57.290344 ±0.3222 ±0.0045	± 1.5	1.2
15	89.0	± 3000 *	0.5
Possible additional channels on upgraded or new instrument:			
-	60.79267 ±0.3539	± 1.5	1.5
-	60.79267 ±0.3558	± 0.4	2.8
-	60.79267 ±0.3569	± 0.25	3.5
-	60.79267 ±0.3579	± 0.5	2.5
-	60.79267 ±0.3589	± 0.25	3.5
-	60.79267 ±0.3600	± 0.4	2.8

Table 3: AMSU-B channel characteristics.

INSTRUMENT: Advanced Microwave Sounding Unit - B			
Channel	Frequency (GHz)	Bandwidth (MHz)	NEAT (K)
16	89.0	± 6000 *	1.0
17	150.0	± 2000 *	1.0
18	183.311 ±1.0	± 250	1.1
19	183.311 ±3.0	± 500	1.0
20	183.311 ±7.0	± 1000	1.2

*In practice the bandwidth of these channels is limited to ±1500 MHz.

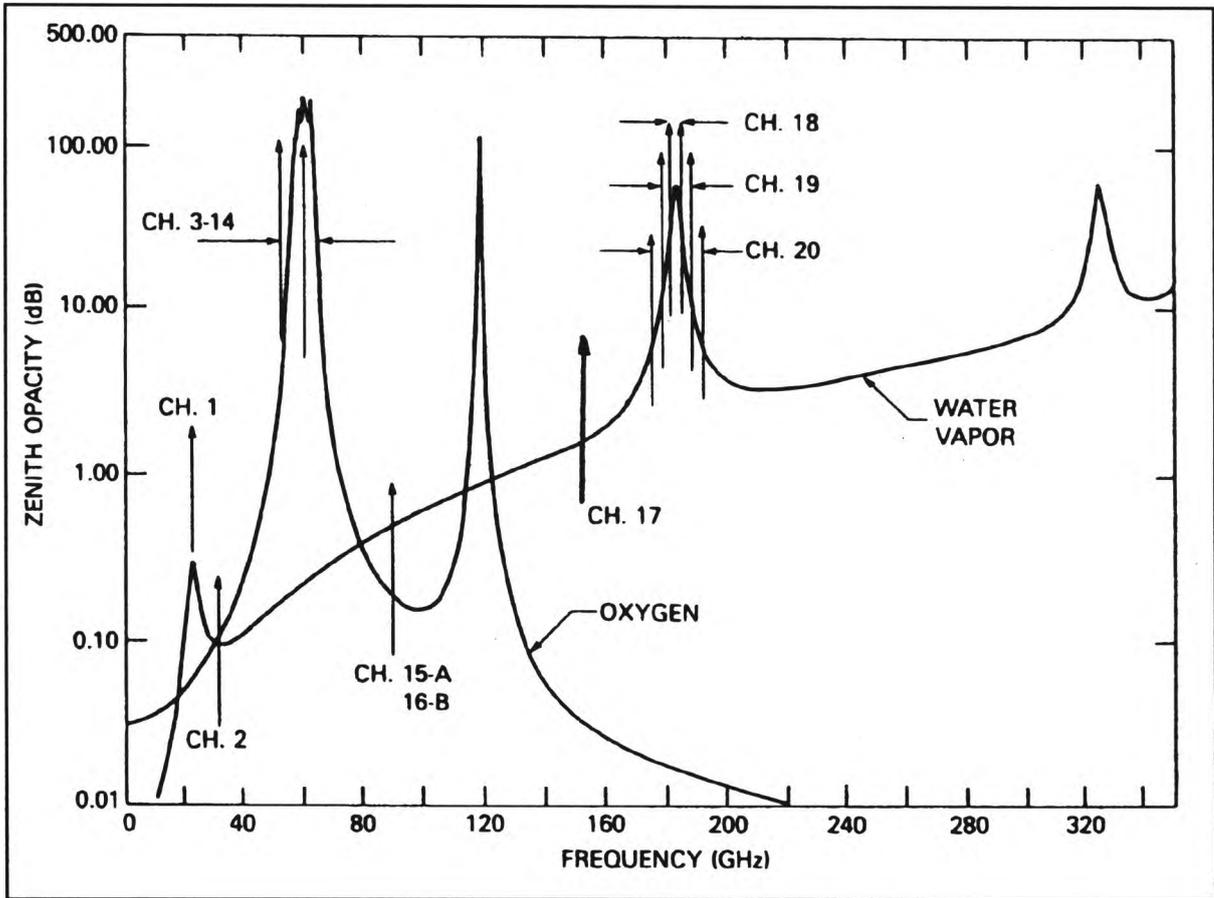


Figure 1: Atmospheric attenuation at microwave frequencies due to oxygen and water vapour molecules, together with the AMSU (A and B) channel positions.

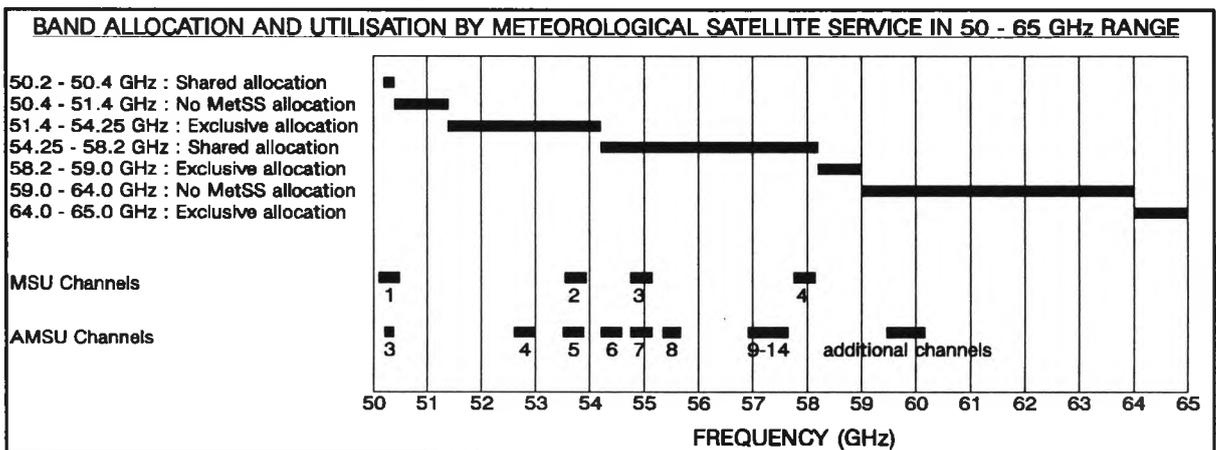


Figure 2: Band allocation as regards the Meteorological Satellite Service, and utilisation by the Meteorological Satellite Service in the 50 - 64 GHz range.

CLOUD MOTION WINDS STATISTICS

INTRODUCTION

The paper assesses the effects of recent changes to the METEOSAT wind extraction scheme on the basis of monthly verification data of cloud motion winds with collocated radiosonde wind measurements. Such verification data are available as monthly averages and are regularly distributed to CGMS members.

There were several changes of the operational METEOSAT cloud motion wind extraction scheme from 1984 to 1990 which either had a noticeable effect or were intended to do so (Schmetz et. al., 1993). Further changes after 1990 were documented in regular quarterly operations reports by ESA. An overall summary is given in Table 1.

CGMS-XXI EUM-WP-14 estimated the effects of method changes in quantitative terms. It used the empirical correlation between speed bias and reference wind speed as a tool to make the resulting performance changes visible, in particular those starting with February 1991 and November 1991. The paper showed that the well known correlation with the speed bias also applies to the RMS vector difference. Since this parameter reflects the quality aspect more closely than the speed bias, this paper considers only the RMS vector differences parameter.

Date	Change
Nov 84	Major revision of the methods for automatic and manual quality control.
Mar 87	Extraction of high level winds after windowing of IR radiances to suppress radiances from lower levels.
Sep 87	New WV channel calibration scheme.
Apr 89	Introduction of ECMWF first guess wind data to initialize the search algorithm for peaks in the correlation surface for high level winds.
Mar 90	Spatial coherence information used as an additional criterion for tracer test and height assignment.
Feb 91	Automatic Quality Control using horizontal wind gradients.
Nov 91	Using VIS data at 7 bits resolution for histogram processing.
Dec 92	Change of image filtering method
Oct 93	Image rectification by cubic spline interpolation

Table 1 Summary of changes to the METEOSAT cloud motion wind extraction scheme since 1984.

This paper provides an updated verification overview and addresses also the performance of medium and low level winds. The two last changes of December 1992 and October 1993 are discussed on the basis

of monthly averages and a long term summary review is given for all periods listed in Table 1. The paper also considers GMS data since October 1989.

METEOSAT HIGH LEVEL WINDS

Scatter diagrams of monthly averages of high level wind RMS vector difference between METEOSAT derived and radiosonde winds are drawn in Fig. 1 for the period from December 1992 to December 1993. It is noted that values are well aligned along a linear regression line except for the two months of February and March 1993 where the RMS vector difference was about 1 m/s greater than expected.

There are two possible reasons which need to be explored further. First, there was a particularly strong radiometer anomaly "fish" observed during the month of February 1993. Second, it seems that there was a meteorological anomaly during these two months whereby the number of satellite derived months was particularly low over the European area - hence, the radiosonde data used for verification were dominated by non-European stations, and in particular by stations over North Africa. It remains to be tested whether wind measurements from these stations are of lower quality than those over Europe and whether this explains the greater differences between the satellite and radiosonde data.

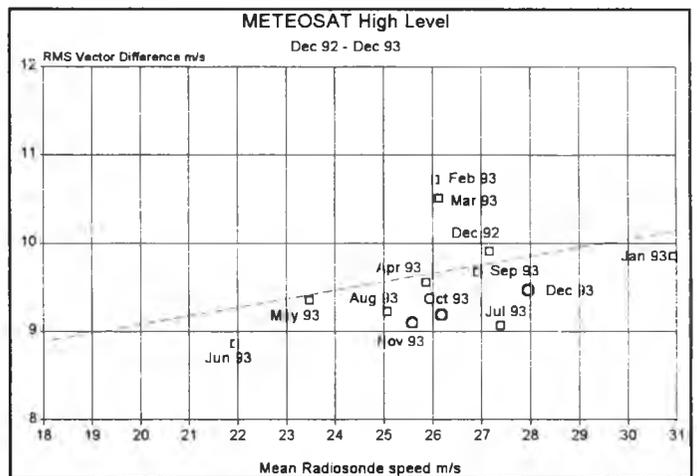


Figure 1: METEOSAT high level winds, scatter diagram of monthly averages of RMS vector difference with radiosonde data. Dashed: regression line.

The regression line in Fig 1 corresponds to the period of December 1992-September 1993 during which the wind extraction scheme was practically unchanged. If these two months were removed from the data set, the RMS vector difference of this period would be smaller by 0.24 m/s. The values of the last three months from October to December 1993 are shown as circles, and show smaller RMS vector differences than the previous period. The improvement relative to the previous period (including the two suspect months) is estimated at about 0.4 m/s.

MEDIUM AND LOW LEVEL

Medium level wind verification data reveal also a negative anomaly for the months of February and March 1993 of the order of almost 1 m/s. If these data did not exist, the RMS vector difference for the whole period would be 0.14 m/s less. In this case, we might conclude that Fig. 2 shows no improvement for the period from October to December 1993. However, these months have a higher average wind speed so that there is indeed an improvement. It can be seen more clearly in Fig. 4.

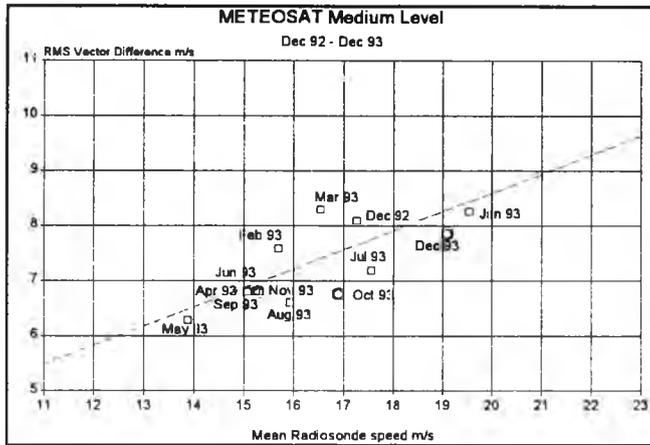


Figure 2: METEOSAT medium level winds, scatter diagram of monthly averages of RMS vector difference with radiosonde data. Dashed: regression line.

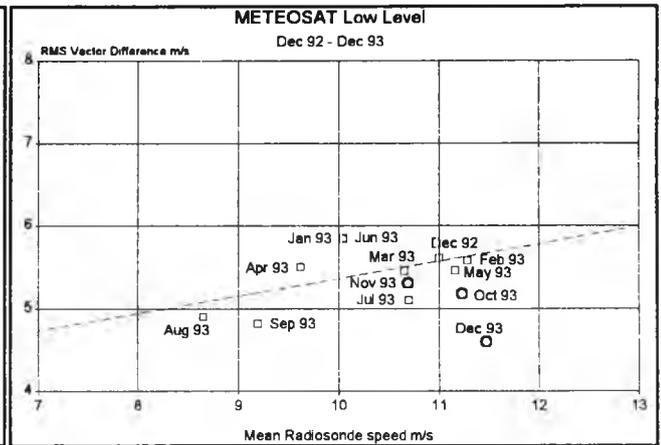


Figure 3: METEOSAT low level winds, scatter diagram of monthly averages of RMS vector difference with radiosonde data. Dashed: regression line.

In the low level wind statistics (see Fig. 3) the months of February and March 1993 show no anomalies. Furthermore, there is a clear improvement for the period from October to December 1993. The reduction of RMS vector difference is estimated at the order of about 0.3-0.4 m/s. This confirms the positive effect of the change of the image rectification method introduced in October 1993 for low level winds.

LONG TERM EVOLUTION - METEOSAT

Long term validation results are shown in Figures 4-6 for high, medium and low level, respectively. GMS wind verification data are merged into the diagrams for comparison purpose.

Considering the apparent correlation between average radiosonde speed and the RMS vector difference, it is taken that the wind extraction method has improved if the vector of the performance change points across the regression lines in the diagrams. For example, the changes between February 1991 and September 1993 correspond to the empirical regression lines and are therefore explained by seasonal meteorological factors. A significant change is apparent only from October 1993 onwards.

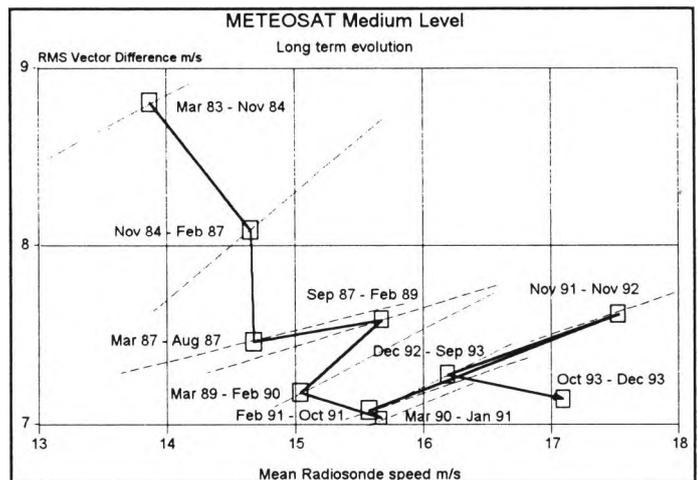


Figure 4: METEOSAT medium level winds, scatter diagram of monthly averages of RMS vector difference with radiosonde data. Dashed: regression lines within individual periods.

LONG TERM EVOLUTION - GMS

The same analysis as for METEOSAT winds was carried out for monthly verification data of GMS winds. Such data have been made available through CGMS since October 1989. Changes of the GMS operational wind extraction scheme have recently been described by Takata (1993):

Date	Change
Apr 90	Major revision of the statistical height assignment table for high level winds
Apr 91	Intensive manual quality control of high level winds and manual height reassignment
Apr 92	Further revision of manual quality control of high level winds
Apr 93	Further revision of the statistical height assignment table for high level winds

Table 2: Summary of changes to the GMS high level cloud motion wind extraction scheme (Takata, 1993).

Monthly verification for GMS high and low level winds were grouped into periods analogous to those of METEOSAT and following the periods shown in Table 2. For comparison with METEOSAT, verification data of winds from both satellites were integrated into the same diagrams separately for the high and low level, respectively (there are no operational medium level winds from GMS). Figures 5 and 6 show that recent progress of GMS winds was greater than for METEOSAT. This result was presented to the wind workshop in Tokyo in December 1993 who congratulated Japan for this success. The workshop noted that this result has been achieved by using external non-satellite information, i.e. radiosonde data, in the wind extraction scheme, and agreed that it would be desirable at long term to minimise the use of any external data, radiosonde or from NWP schemes.

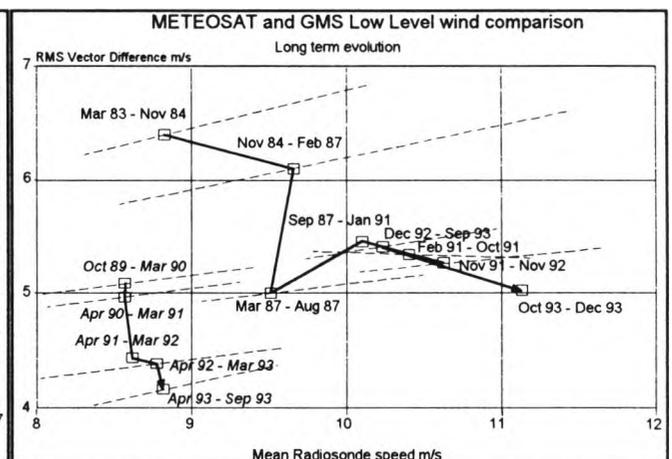
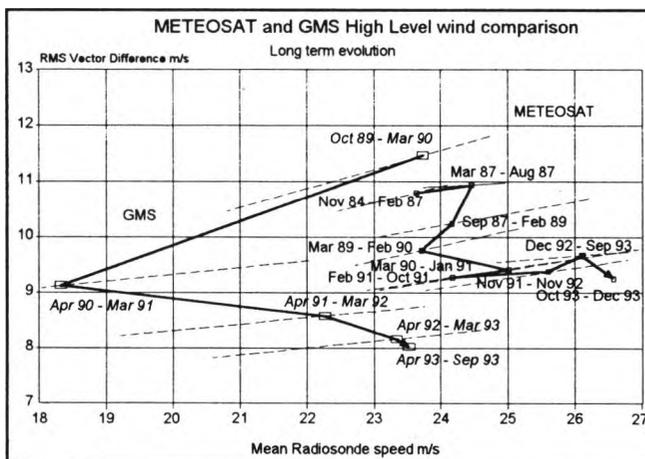


Figure 5: METEOSAT and GMS long term evolution of high level winds. Dashed: regression lines within individual periods. **Figure 6:** METEOSAT and GMS long term evolution of low level winds. Dashed: regression lines within individual periods.

CONCLUSION

Further improvement of the operational wind extraction scheme from METEOSAT data has been demonstrated at all three height levels, i.e. high, medium and low level winds. The introduction of the cubic spline rectification method had a positive effect. Since only three months of data have been available since the introduction of this method, and since there was a strong anomaly of wind verification data in early 1993, it is not advisable at this time to estimate the effect in quantitative terms.

GMS winds had a remarkable progress since April 1990 for both, high and low level winds. This is largely due to refinements of the statistical and manual height assignment method and improved manual quality control.

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Schmetz, Holmlund, Hoffman, Strauss, Mason, Gaertner, Koch, Van de Berg: Operational Cloud-Motion Winds from METEOSAT infrared images; *J. Appl. Met.*, Vol. 32, No. 7, July 1993.

Takata: Current status of GMS wind and operational low-level wind derivation in a typhoon vicinity from short-time interval images. To appear in: *Proceedings of the Second International Wind Workshop held in Tokyo, Japan, 13-15 December 1993*

CGMS WORKING PAPERS 13, 14, 16

PRESENTED BY JAPAN

Plans for GMS-5 Products

The purpose of this paper is to introduce plans for GMS-5 products and information on the development of the processing system.

Monitoring of GMS visible image data

The purpose of this document is to introduce the result of monitoring of the GMS-3 and GMS-4 visible image data for a long term and the method to correct the long term decreasing tendency of GMS visible reflectance.

Current Status of GMS Wind Derivation

The purpose of this document is to introduce the improvements of GMS high-level cloud motion winds from 1990.

Plans for GMS-5 Products

Geostationary Meteorological Satellite - 5 (GMS-5) has additional observation spectral bands to those of the current satellite as shown in the following table:

Channel	GMS-4	GMS-5	
Visible	0.5 to 0.75 μ m	0.55 to 0.90 μ m	
Water Vapor	None	6.5 to 7.0 μ m	Ch.3
Thermal	10.5 to 12.5 μ m	10.5 to 11.5 μ m	Ch.1
Infrared		11.5 to 12.5 μ m	Ch.2

It is planned that modification of the ground communication system and replacement of computer system in the Meteorological Satellite Center (MSC) will be performed before launch of the GMS-5, and also some new products will be derived and some will be improved using the image data from the sensors mentioned above. Some products will be disseminated to users via GMS-5 or GTS. Major products are described as follows:

(1) Stretched VISSR

All VISSR data will be disseminated to MDUS users through GMS-5. Image data of thermal infrared channel 2 (one of the split window channels) and water vapor channel will be newly provided.

Calibration tables and calibration coefficients will be additionally disseminated. Brightness temperature and/or albedo can be derived from brightness level of image data by referring the calibration tables. Also radiance can be calculated by using the calibration coefficients. The additional data will be put into unused blocks in the current format.

These modifications of dissemination formats will hardly affect the MDUS users as long as they continue to utilize the current image data of the visible channel and infrared channel 1 (one of the split window channels).

(2) WEFAX

Four-sectorized infrared images will be made from a rectified (mapped) disk images in

place of a non-rectified (observed) disk image. The rectified disk image is equivalent to the disk image observed from a nominal geostationary position above the equator with a nominal attitude, *i.e.*, the spin axis exactly vertical to the orbital plane.

SDUS users will be able to make an animation of four-sectorized images without geographical fluctuation caused by temporal variation of spacecraft position and attitude.

Four-sectorized water vapor images observed at 00 and 12 UTC will be newly disseminated. Formats of these images are the same as that of four-sectorized infrared images.

(3) Satellite Wind

The satellite winds at the middle level atmosphere will be newly derived from WV images in addition to the current satellite winds at the high level and low level atmosphere.

Water vapor wind will be derived at middle- and high-level from the water vapor channel images using the same tracking technique based on cross-correlation method as one currently used for high and low level satellite winds derivation. Techniques of target selection and height assignment to the resultant winds to be introduced are still under investigation.

The low level and high level cloud motion winds will continue to be derived from the visible channel and the infrared channel 1 image. It is planned to improve the accuracy of the height assignment of cloud motion winds through the combination of the water vapor channel and the split window channels.

Numerical weather prediction data will be used as reference data to check the quality of satellite winds.

(4) Sea Surface Temperature

Sea surface temperatures (SST) will be estimated with better accuracy compared with the current method since the atmospheric correction will be improved using the temperature difference of the split window channel data.

JMA has been developing operational SST algorithms for GMS-5 data using the technique based on MCSST (Multi-Channel Sea Surface Temperature) retrieval algorithms which are currently used for SST extraction from the NOAA AVHRR split window channel data. In addition, the algorithm to identify cloud-free and cloud-filled pixels will be the same as the current histogram analysis algorithm.

(5) Cloud Amount

Cloud amount will continue to be operationally derived from one of the split window channels data. The processing method will not be basically changed, but the accuracy of

extractions will be improved since the accuracy of cloud height assignment is improved by using a method to estimate semitransparent cirrus height from the observed data of one of the split window channels and water vapor channel together with finer vertical profiles from numerical weather forecasting.

(6) Equivalent Black Body Temperature / Outgoing Longwave Radiation

Equivalent black body temperature will continue to be derived by using one of split window channels data. The processing method will not be changed. This product has been used for a semi-real-time monitoring of the convective activity in the tropical region as an index of Outgoing Longwave Radiation (OLR).

The OLR will be newly derived from the combination of the split window channels data and the water vapor channel data.

(7) Upper Tropospheric Air Humidity

Upper Tropospheric Air Humidity means the mean relative humidity in the layer between middle and upper troposphere.

The humidity data will be newly derived from the GMS-5's water vapor channel data and vertical profiles from numerical weather forecasting.

JMA has been developing the GMS-5's humidity processing system by using the ESA's algorithm which is used for processing the humidity data from the Meteosat water vapor channel data.

(8) Precipitable Water Amount

Precipitable water amount will be newly derived from the split window channels data.

An algorithm for deriving precipitable water amount is based on the multiple regression analysis between the split window channels data and the precipitable water amount obtained from the data of radiosoundings.

JMA has been developing the algorithm for the GMS-5 operation with reference to the results of the investigation by the split window channels data of GOES and NOAA data.

(9) Satellite-derived Index of Precipitation Intensity

Satellite-derived Index of Precipitation Intensity (SI) is derived by using the multiple regression analysis between the GMS (VIS and IR) data and the digital radar data. The SI data are used for very short range forecasting of precipitation as supplemental data outside the effective coverage of meteorological digital radar network.

The accuracy of SI in the nighttime is not so high as in the daytime due to the adverse effect of thin cirrus clouds which do not cause precipitation. The technique for merging split window data into the current regression equations is under development in the Meteorological Satellite Center since split window data available from GMS-5 is useful for eliminating the adverse effect of the thin cirrus cloud.

The accuracy of SI in the nighttime will be improved by the new regression equations.

(10) Satellite Cloud Analysis Chart

The Satellite Cloud Analysis Chart (SCAC) will be automatically produced through a cloud classification algorithm using the split window and water vapor data as the first step.

Several cloud types, including fog/stratus, convective cloud and cirrus will be objectively delineated by using the algorithm. JMA has been developing the algorithm from the split window and water vapor data of MOS-1 and GOES.

In addition, the information on significant meteorological phenomena will be manually added to the SCAC by means of man-machine interactive operation.

(11) Typhoon Analysis

The center location and intensity of typhoon will continue to be estimated by interactive processing of four channel data.

The accuracy of the center location of typhoon in the nighttime will be improved since low and high level clouds can be easily delineated from the temperature difference of the split window channel data.

(12) WCRP products

International Satellite Cloud Climatology Project (ISCCP) and Global Precipitation Climatology Project (GPCP) data will continue to be derived and archived.

Monitoring of GMS visible image data

Quantitative evaluation of changes in natural environment of the earth through continuous monitoring is one of the main themes in the many fields of the earth science. The GMS visible image data are suitable for monitoring of broad area solar irradiance and snow distribution. However it is one of the main problems that the GMS visible image data may have a decreasing tendency of reflectances with time according as the sensitivity of the visible channel detectors declines for a long term. Therefore it is important to monitor the GMS visible image data for a long term. The preliminary results of monitoring the GMS-3 and the GMS-4 visible image data and the method to correct decreasing value of reflectance with time are shown in the attachment. The results are as follows.

The data used are extracted from histograms of full visible disk image data at 00, 03 and 06 UTC from 1 October 1985 to 16 November 1994. Digital counts equivalent to the five levels, 99.9, 98.0, 90.0, 70.0 and 40.0 percentile of each histogram are extracted and then converted to the reflectances by the calibration procedure. The five data sets are respectively prepared from the reflectances for the five level percentiles of each histogram for the three observation times.

As a result of analysis, it is found out that the trends of reflectances in the five categories for operating periods of the GMS-3 and the GMS-4 show the seasonal variation of reflectances in consequence of the change of the relationship between the sun and the earth and a decreasing tendency of reflectances with time mainly according as the sensitivity of the detector of the GMS visible channel declines.

In order to correct the decreasing tendency of reflectance with time, the following procedure is considered as a practical way. Firstly the equations showing the decreasing trend of reflectance with time in five categories by observation times are estimated by applying the least square method as it is assumed that the decreasing tendency of the GMS-3 can be approximated with a quadratic line, while that of the GMS-4 can be approximated with an exponential line considering the extremely decline of reflectances for a few years elapsed since the operation of the GMS-4 is started. Secondly the equations to correct the observed reflectance to a value corresponding to the start time of the GMS-3 and the GMS-4 operations respectively are derived on a basis of the equations mentioned above. Finally the corrected reflectances of the GMS-4 are corrected the reflectances corresponding to the start time of the GMS-3 operation. In these procedures, the long term visible image data of the GMS-3 and the GMS-4 can be treated quantitatively.

The examination of the derived equation for its validity is now under consideration by the MSC. After then the method is expected to use for correcting the long term decreasing tendency of GMS visible reflectance as the pretreatment on estimating solar irradiance and snow distribution by GMS visible reflectances. CGMS members are required to comment about the method proposed in this paper.

Preliminary results of GMS visible image data monitoring (Draft)**Masami Tokuno and Hiroki Itaya***Meteorological Satellite Center, Japan Meteorological Agency***Introduction**

Recently quantitative evaluation of changes in natural environment of the earth through continuous monitoring is one of the main themes in the many fields of the earth science. The geostationary meteorological satellite (GMS) has the advantage of taking homogeneous data globally in a short time. Especially the GMS visible image data are suitable for monitoring of broad area solar irradiance and snow distribution. However it is one of the main problems that the GMS visible image data may have a decreasing tendency of reflectances with time according as the sensitivity of the visible channel detectors declines for a long term. Therefore it is important to monitor the GMS visible image data for a long term. The preliminary result of monitoring the GMS-3 and the GMS-4 visible image data and the method to correct decreasing value of reflectance with time are shown in this paper.

Data

The data are extracted from histograms of full visible disk image data at 00, 03, 06 UTC from 1 October 1985 to 16 November 1994. Digital counts equivalent to the five levels, 99.9, 98.0, 90.0, 70.0 and 40.0 percentile of each histogram are extracted and then converted to the reflectances by the calibration procedure in the MSC. The five data sets (A1 to A5) by the three observation times respectively prepared from the reflectances for the five level percentiles of each histogram. The total term of each data set is 1860 days for the GMS-3 and 1440 days for the GMS-4.

Results

Figs.1 to 6 indicate the trend of reflectances in the five categories by the three observation times for operating periods of the GMS-3 and the GMS-4. The ordinate indicates the reflectance, while the abscissa indicates the days elapsed since the operation of the GMS-3 and the GMS-4 are started respectively. The figures show an extremely short variation of reflectances and a decreasing tendency of reflectances with time. The former is considered as the seasonal variation in consequence of the change of the relationship between the sun and the earth. The latter suggests a long term sensitivity degradation of the detector of GMS visible channel. The results require a suitable correction of the decreasing tendency of reflectance with time to extract the physical values from the GMS visible data for a long term.

Therefore the decreasing rate of reflectance with time are estimated by applying the least-square method. In calculation it is assumed that the decreasing tendency of the GMS-3 can be approximated with a quadratic line, while that of the GMS-4 can be approximated with an exponential line considering the extremely decline of reflectances for a few years elapsed since the operation of the GMS-4 is started. A quadratic equation and an exponential equation can be expressed as

$$y = A_1 t^2 + B_1 t + C_1 \quad (1)$$

$$y = \exp (B_2 - A_2 t) + C_2 \quad (2)$$

where y stands for the reflectance, t is the time (unit : day) elapsed since the operations of the GMS-3 and the GMS-4 are started and $A_1, B_1, C_1, A_2, B_2, C_2$ are coefficients to be calculated. These coefficients by the three observation times are determined in every five categories by applying the least-square method. The coefficients obtained are shown in Table 1 and 2 and the results of the calculation are shown as curves in the figures. As expected, remarkable decrease in reflectance appears with higher percentile categories.

In order to correct decreasing value of reflectance with time the following procedure is considered as a practical way. In the case of the GMS-3, the coefficient C_1 in the equation (1) stands for the reflectance at the start time of the GMS-3 operation by correcting the reflectance y observed at one time. Therefore the corrected reflectance can be derived in the equation (3) from the equation (1).

$$R_3(\text{corrected}) = R_3(\text{observed}) - (At^2 + Bt) \quad (3)$$

where $R_3(\text{corrected})$ stands for the reflectance at the start time of the GMS-3 operation, $R_3(\text{observed})$ is the reflectance observed in the day (t) elapsed since the operation of the GMS-3 is started and A and B are coefficients. The coefficients A and B can be respectively determined by interpolating every coefficients A_1 and B_1 obtained in the five categories by the three observation times.

In the case of the GMS-4, the same procedure mentioned above is carried out. As a results, the corrected reflectance can be obtained in the equation (4) from the equation (2).

$$R_4(\text{corrected}) = R_4(\text{observed}) - \exp(B - At) + \exp(B) \quad (4)$$

The coefficients A and B can be also determined by interpolating every coefficients A_2 and B_2 obtained in the five categories by the three observation times.

Considering the difference in sensitivity of the detector of visible channel between the GMS-3 and the GMS-4 at the start time of the operation, the corrected reflectance R_4 is corrected to the reflectance corresponding to the start time of the GMS-3 operation in the equation (5).

$$R_3(\text{corrected}) = CR_4(\text{corrected}) \quad (5)$$

The coefficient C can be determined by interpolating every coefficients C_3 shown in Table 3

which are the ratio of the value (C_1) at $t = 0$ in the equation (1) to the value ($\exp(B_2) + C_2$) at $t = 0$ in the equation (2) in the five categories by the three observation times.

In these procedures, the long term visible image data of the GMS-3 and the GMS-4 can be treated quantitatively.

Concluding Remarks

The visible image data of the GMS-3 and the GMS-4 are examined. It is found out that reflectances extracted from visible image data have an seasonal variation and decreasing tendencies with time : a quadratic trend for the GMS-3 and a exponential trend for the GMS-4. A quadratic equation for the GMS-3 and a exponential equation for the GMS-4 are derived for correcting the long term decreasing tendencies of reflectances. The examination of the derived equation for its validity is now under consideration. After then the method is expected to use for correcting the long term decreasing tendency of GMS visible reflectance as the pretreatment on estimating solar irradiance and snow distribution by GMS visible reflectances. At satellite operating agencies, various procedures may be carried out to correct the long term decreasing tendencies of reflectances. It would be desirable to formulate a procedure to correct the decreasing tendency so that the data can be utilized globally for scientific purpose.

Table 1 Coefficients of a quadratic equation by the three observation times in every five categories which are extracted from the five levels, 99.9, 98.0, 90.0, 70.0 and 40.0 percentile of each histogram in GMS-3 visible image data.

Time (UTC)	Coeff.			
	Categories	A_1 ($\times 10^{-6}$)	B_1 ($\times 10^{-3}$)	C_1
0 0	A 1 (99.9 %)	1.3429	-10.8508	75.45
	A 2 (98.0 %)	1.8395	-11.6759	51.63
	A 3 (90.0 %)	1.4162	-5.8865	25.64
	A 4 (70.0 %)	0.6939	-2.5770	10.09
	A 5 (40.0 %)	0.3117	-0.9653	3.30
0 3	A 1 (99.9 %)	0.9382	-9.6930	80.21
	A 2 (98.0 %)	0.0000	-7.3488	60.73
	A 3 (90.0 %)	1.6134	-7.4655	35.19
	A 4 (70.0 %)	0.4485	-2.5224	16.63
	A 5 (40.0 %)	0.2076	-1.1730	6.58
0 6	A 1 (99.9 %)	0.8455	-7.9265	72.15
	A 2 (98.0 %)	1.2072	-8.4031	50.89
	A 3 (90.0 %)	0.7928	-3.9311	25.29
	A 4 (70.0 %)	0.4148	-1.7875	10.38
	A 5 (40.0 %)	0.0000	-0.2478	2.79

Table 2 Same as Table 1 except for coefficients of a exponential equation in GMS-4 visible image data.

Time (UTC)	Coeff.	A_2 ($\times 10^{-3}$)	B_2	C_2
	Categories			
0 0	A 1 (99.9 %)	0.6251	2.8861	50.54
	A 2 (98.0 %)	1.0824	2.9634	28.64
	A 3 (90.0 %)	0.9574	2.1545	14.65
	A 4 (70.0 %)	0.7758	1.3025	5.31
	A 5 (40.0 %)	0.8379	0.3051	1.66
0 3	A 1 (99.9 %)	1.4264	2.9936	58.62
	A 2 (98.0 %)	1.1083	3.1444	36.66
	A 3 (90.0 %)	1.5551	2.5323	21.61
	A 4 (70.0 %)	1.1214	1.7586	10.01
	A 5 (40.0 %)	0.7667	0.9755	3.81
0 6	A 1 (99.9 %)	0.6545	2.7860	50.54
	A 2 (98.0 %)	1.0449	2.8880	29.48
	A 3 (90.0 %)	0.8862	2.1116	14.96
	A 4 (70.0 %)	0.9253	1.3797	5.86
	A 5 (40.0 %)	0.6991	0.3125	1.37

Table 3 Same as Table 1 except for the ratio of the reflectance in the GMS-3 to that in the GMS-4 at the start of the operation.

Time (UTC)	Coeff. Categories	C ₃
0 0	A 1 (99.9 %)	1.102
	A 2 (98.0 %)	1.076
	A 3 (90.0 %)	1.102
	A 4 (70.0 %)	1.123
	A 5 (40.0 %)	1.094
0 3	A 1 (99.9 %)	1.021
	A 2 (98.0 %)	1.014
	A 3 (90.0 %)	1.029
	A 4 (70.0 %)	1.052
	A 5 (40.0 %)	1.018
0 6	A 1 (99.9 %)	1.081
	A 2 (98.0 %)	1.073
	A 3 (90.0 %)	1.089
	A 4 (70.0 %)	1.056
	A 5 (40.0 %)	1.019

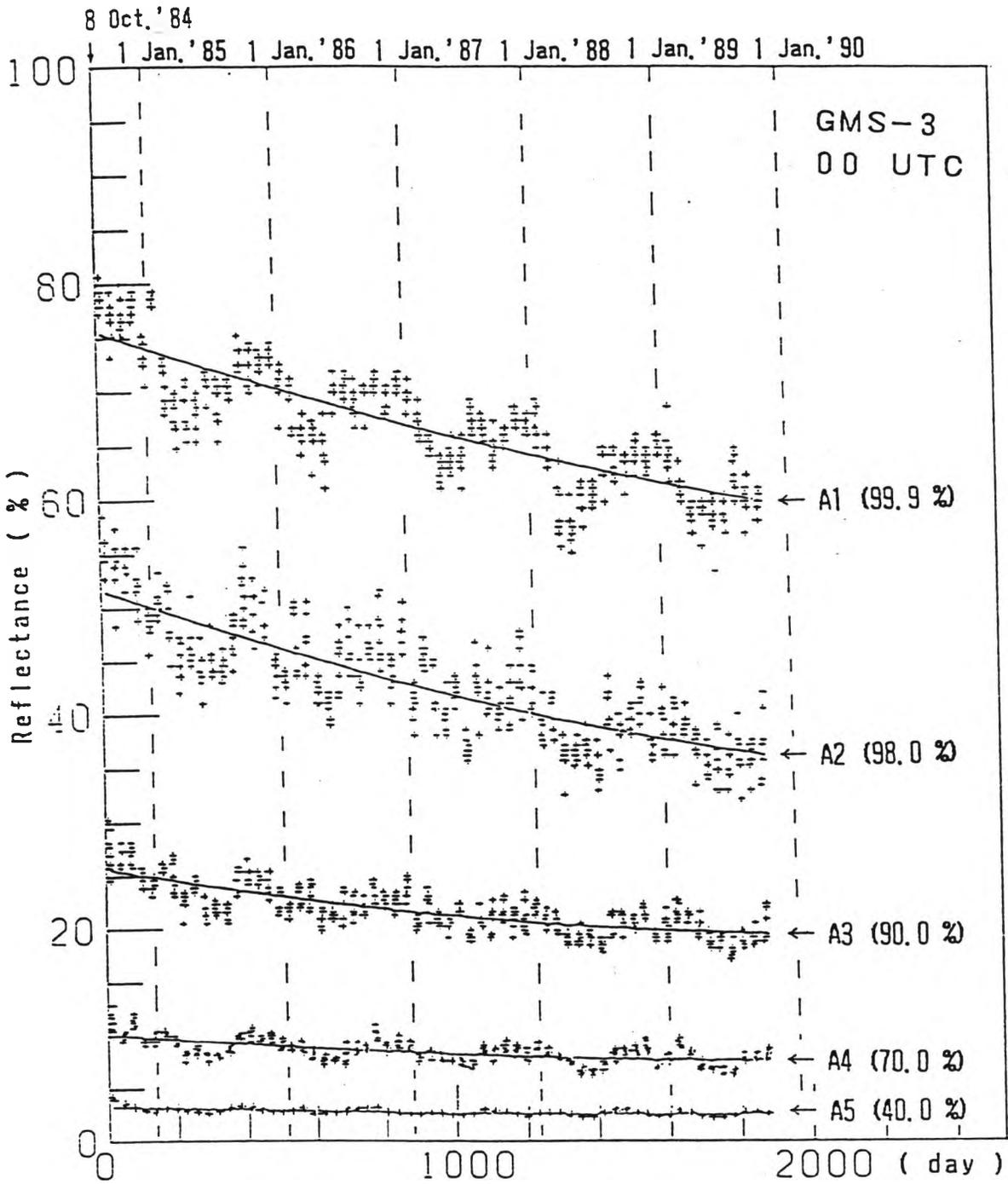


Fig.1 The trend of reflectances in five categories at 00 UTC for operating periods of the GMS-3. The ordinate indicates the reflectance and the abscissa indicates the day elapsed since the operation of the GMS-3 is started.

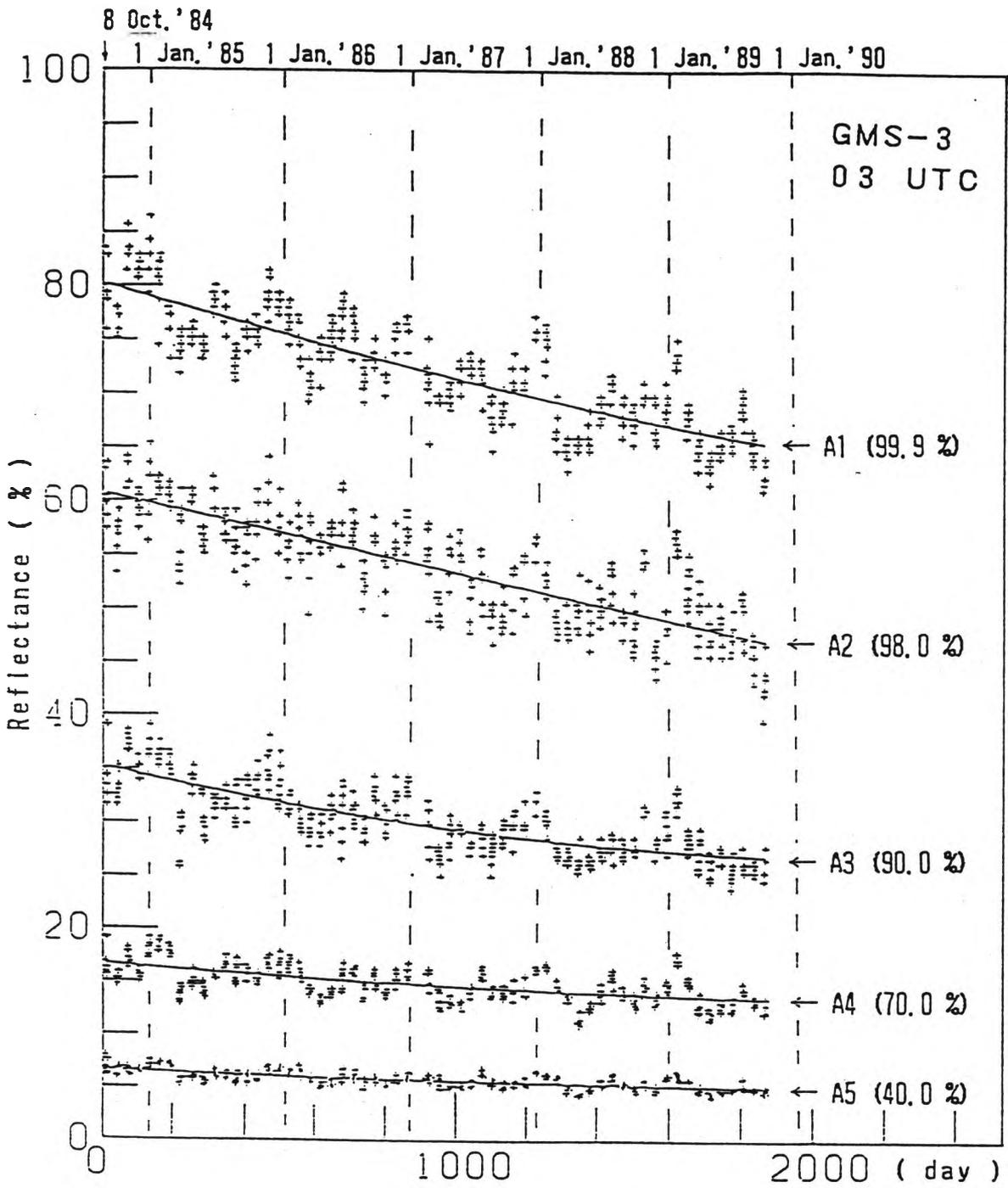


Fig.2 Same as Fig.1 except for at 03 UTC.

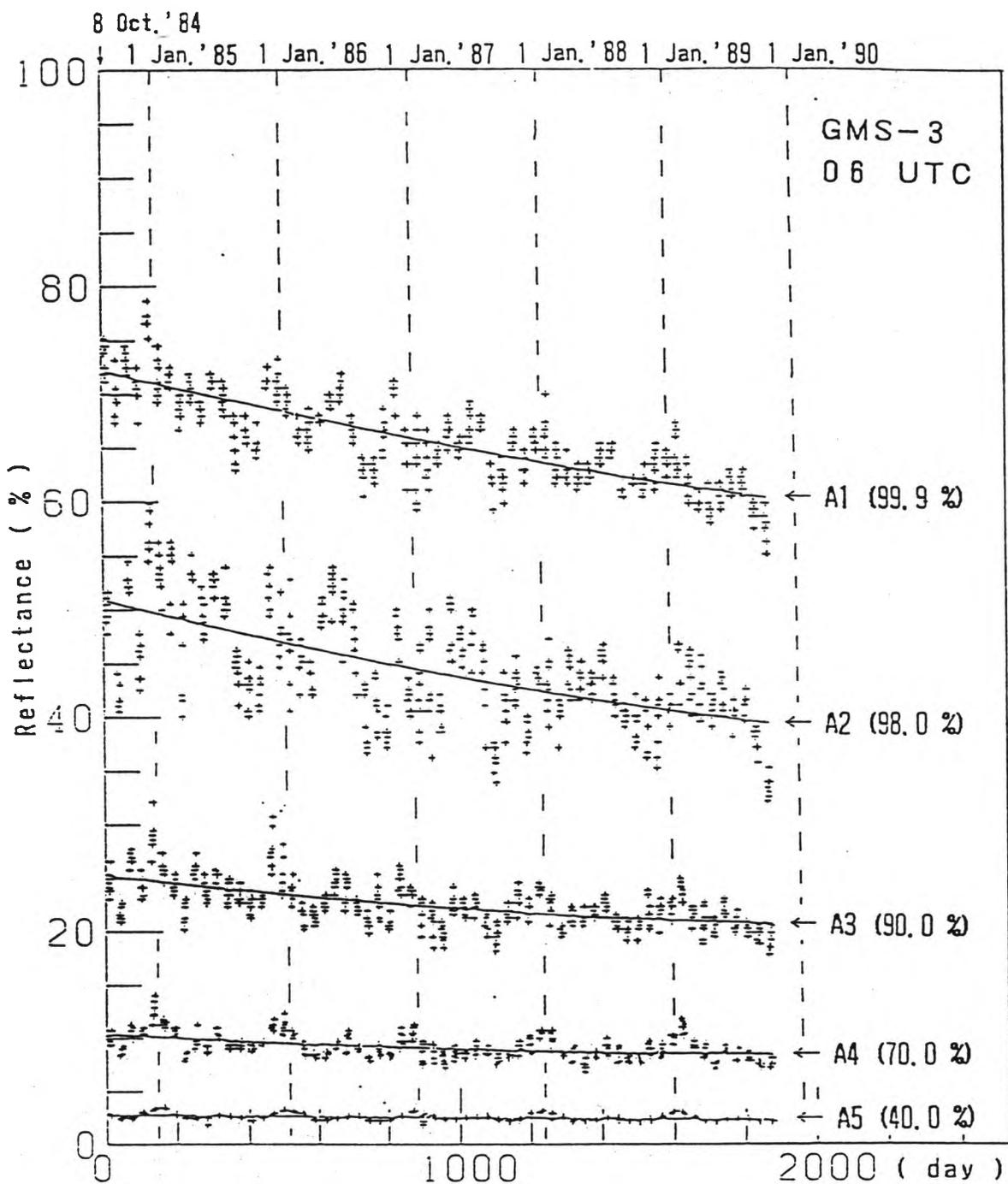


Fig.3 Same as Fig.1 except for at 06 UTC.

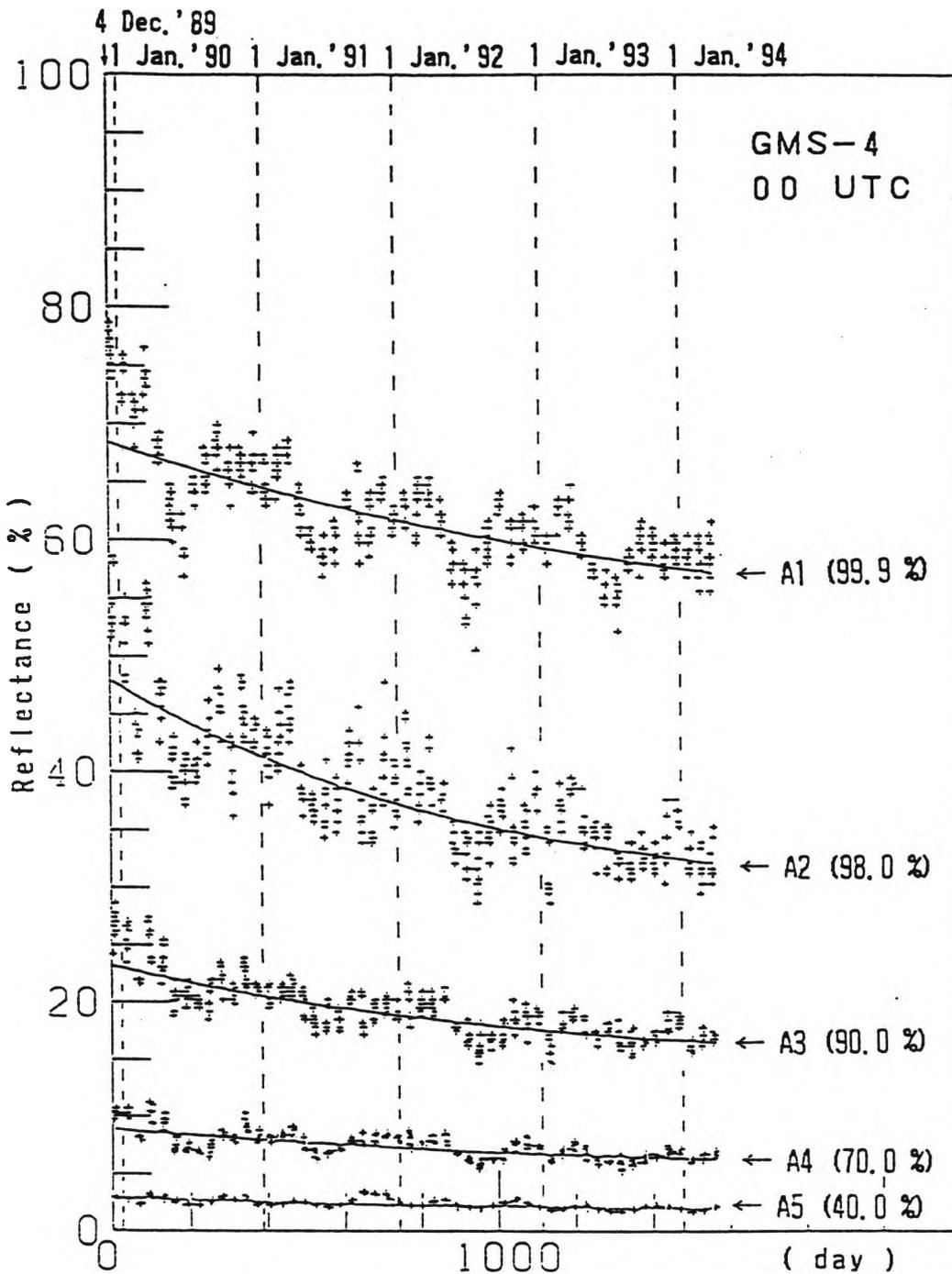


Fig.4 The trend of reflectances in five categories at 00 UTC for operating periods of the GMS-4. The ordinate indicates the reflectance and the abscissa indicates the day elapsed since the operation of the GMS-4 is started.

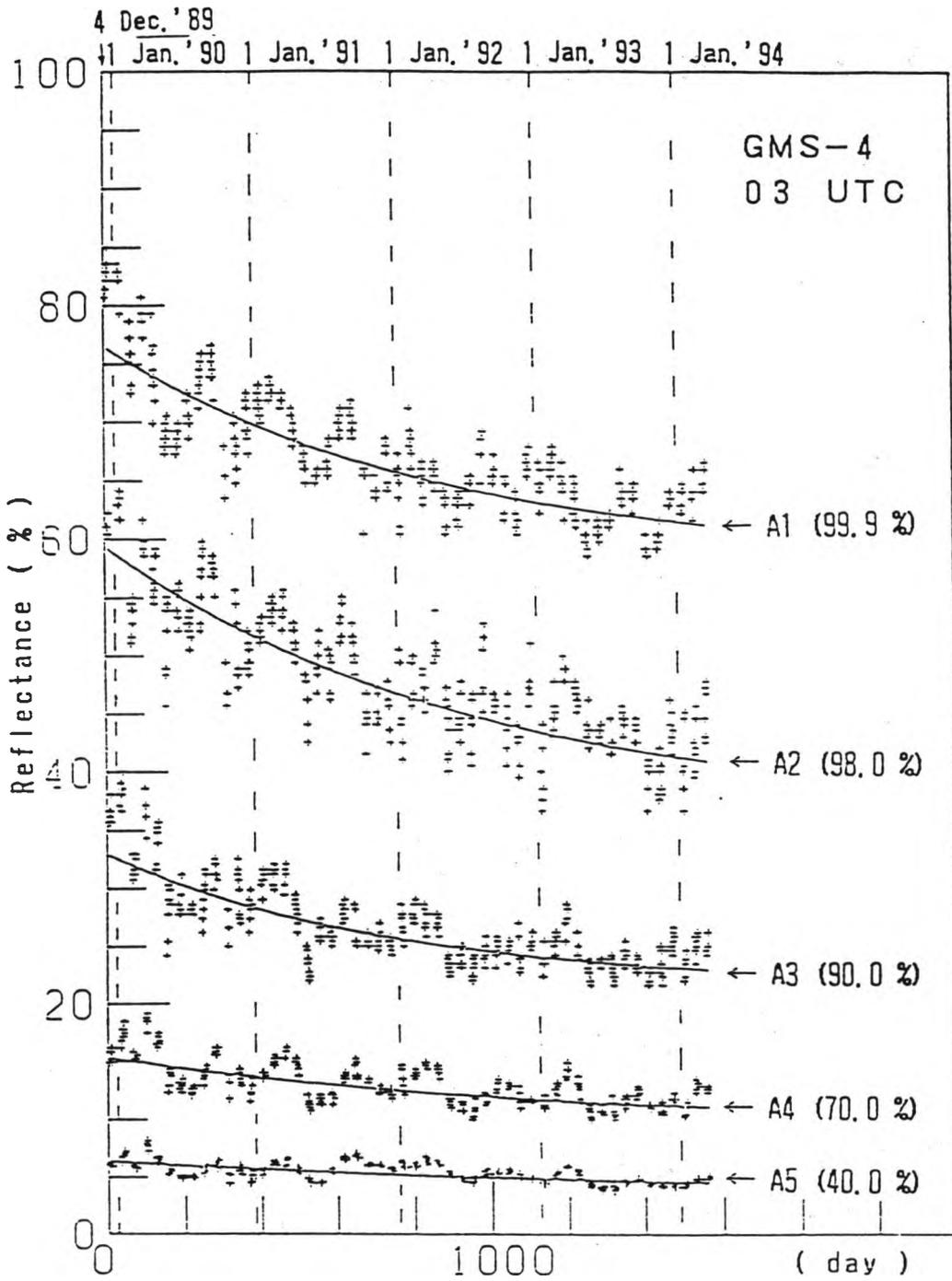


Fig.5 Same as Fig.4 except for at 03 UTC.

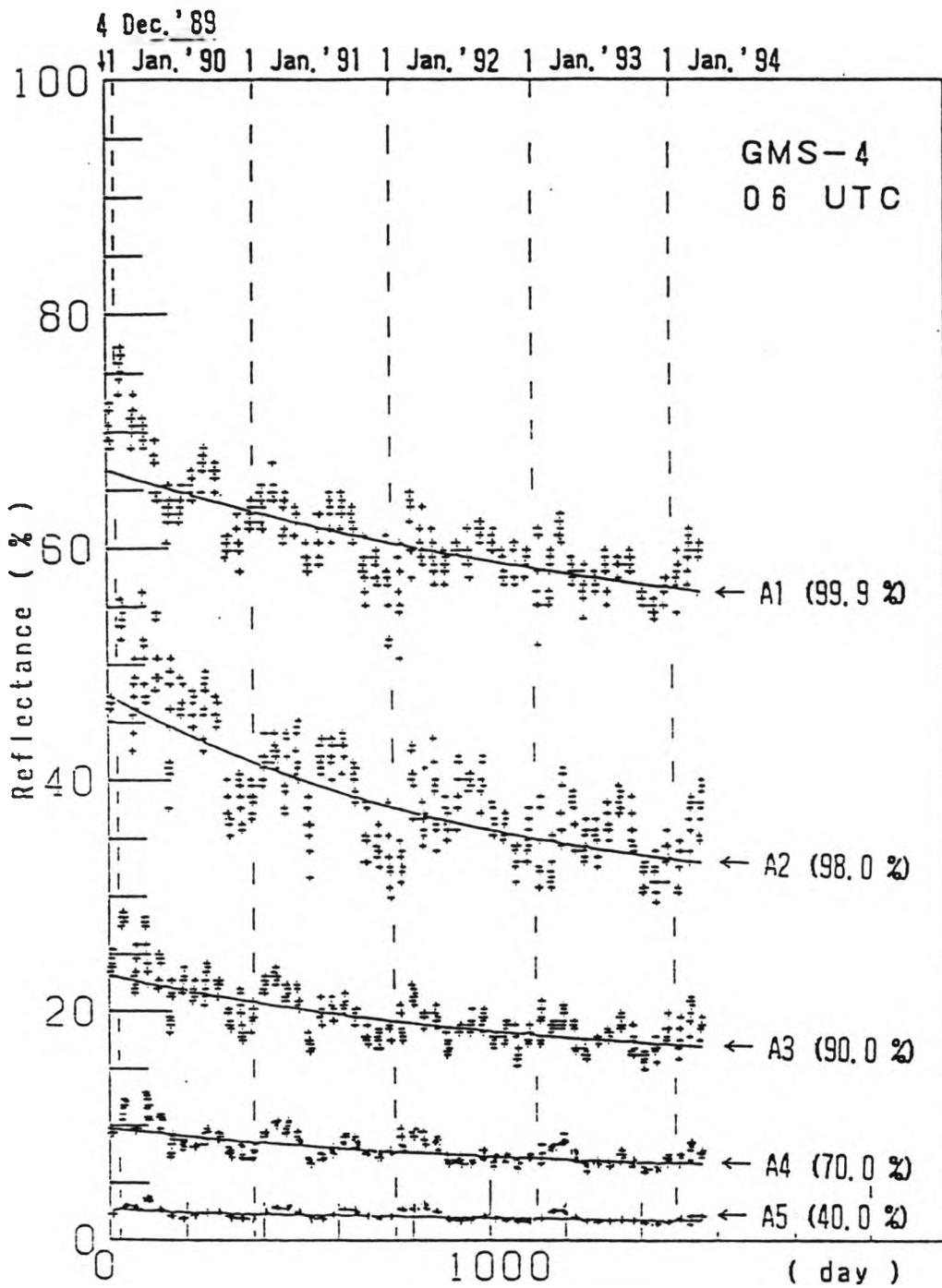


Fig.6 Same as Fig.4 except for at 06 UTC.

Current Status of GMS Wind Derivation

1. Introduction

The Meteorological Satellite Center has made effort concentrated on the improvement of GMS high-level Cloud Motion Winds (CMWs). To improve the quality of high-level CMWs, three changes to height assignment method and the improved manual quality control software were introduced in operation to date after the employment of automatic wind extraction scheme in 1987. Those are as follows;

- (a). The revision of height assignment table as from April 1990.
- (b). The introduction of intensive manual quality control technique for the area around the Jet Stream as from April 1991 including reassignment of wind height assigned automatically.
- (c). The employment of improved manual quality control software as from April 1992.
- (d). The second revision of height assignment table as from April 1993.

2. Evaluation

To evaluate the modifications of the height assignment method and the employment of improved manual quality control software, the monthly mean differences between high-level CMWs and radiosonde winds were calculated in the same way as the International Comparison of the Satellite Winds. Vector and speed differences over two latitudinal areas, that is 50°N – EQ. area (the Northern Hemisphere) and EQ. – 50°S area (the Southern Hemisphere), from April 1989 to January 1994 are shown in Figs. 1 and 2.

In 50°N – EQ. area, the major improvements of vector and speed differences are after the revision of height assignment table in April 1990. Annual means of RMS vector difference before and after April 1990 are 10.9 m/s and 8.8 m/s respectively. Those of speed bias are -3.0 m/s and -0.9 m/s respectively. Smaller improvements are seen by the method changes and the employment of improved manual quality control software in April 1991, 1992 and 1993.

On the other hand, in EQ. – 50°S area, the improvements after the employment of improved manual quality control software in 1992 are remarkable. Yearly RMS vector differences in June from 1990 to 1993 in Fig. 1 are 14.7 m/s, 13.1 m/s, 10.5 m/s and 9.4 m/s respectively. Those of speed bias in Fig. 2 are -8.3 m/s, -5.7 m/s, -2.1 m/s and -1.9 m/s respectively. Both of them are improved though mean CMWs speed increases from 22.1 m/s in 1990 to 27.4 m/s in 1993 through 25.4 m/s in 1991 and 26.6 m/s in 1992. Annual means of RMS vector difference before and after April 1992 are 9.6 m/s and 9.1 m/s respectively. Those of speed bias are -2.0 m/s and -1.9 m/s respectively.

The average values of RMS vector differences after April 1993 in 50°N – EQ. and EQ. –

50°S areas are 7.8 m/s and 8.7 m/s respectively. Those of speed bias are -1.0 m/s and -1.1 m/s respectively.

3. Results

The results of comparisons are summarized that;

- (1). The quality of high-level CMWs was improved in stages corresponding to the changes to the height assignment method and the employment of improved manual quality control software from April 1990 despite the increasing mean CMWs speed.
- (2). The biggest improvement was achieved in EQ. - 50°S area after the employment of new software in April 1992.
- (3). The difference in quality between high-level CMWs in 50°N - EQ. and EQ. - 50°S areas becomes small after the second revision of the height assignment table in April 1993.

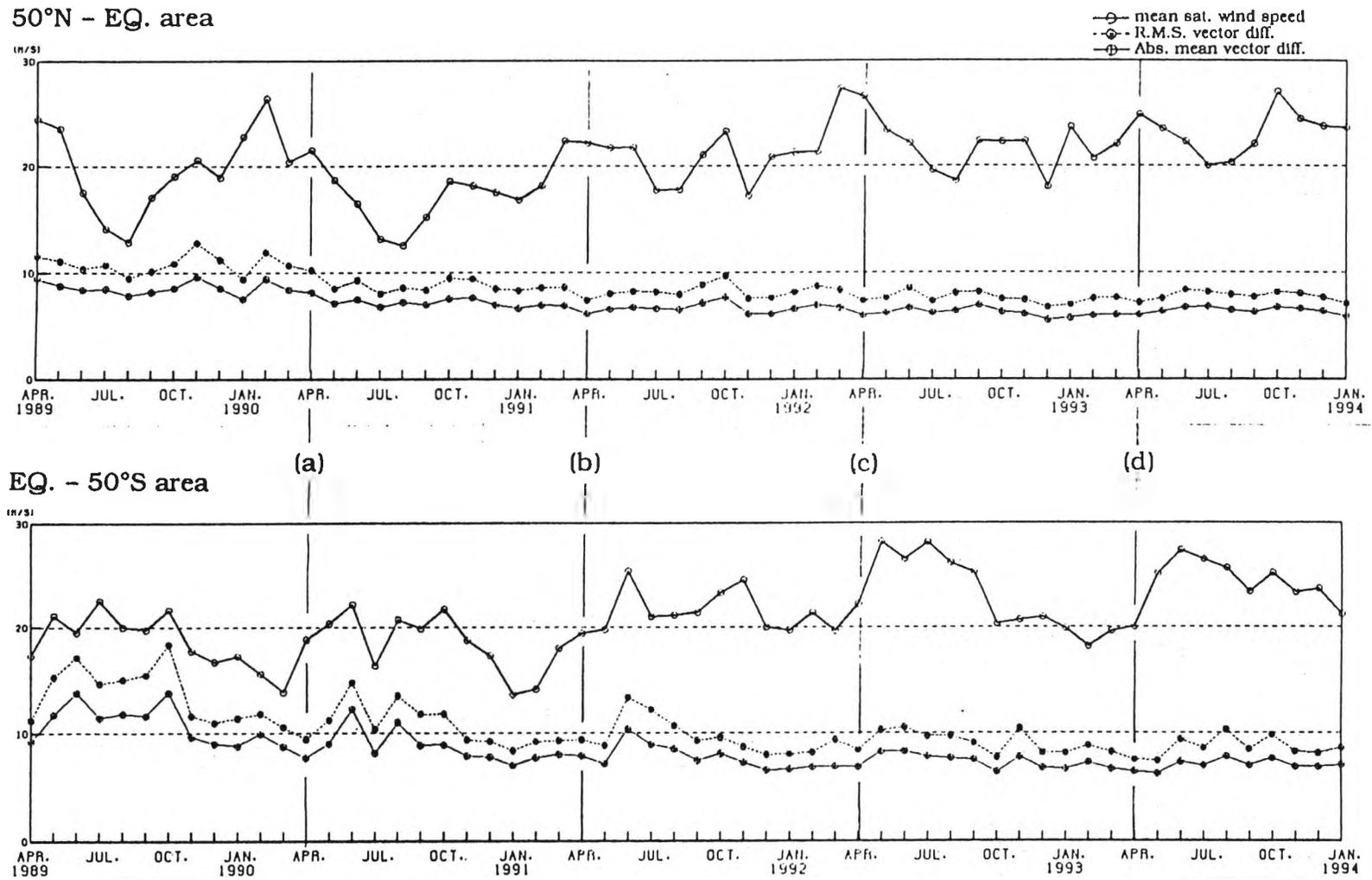


Fig. 1. Monthly means of vector difference between high-level CMWs and radiosonde wind

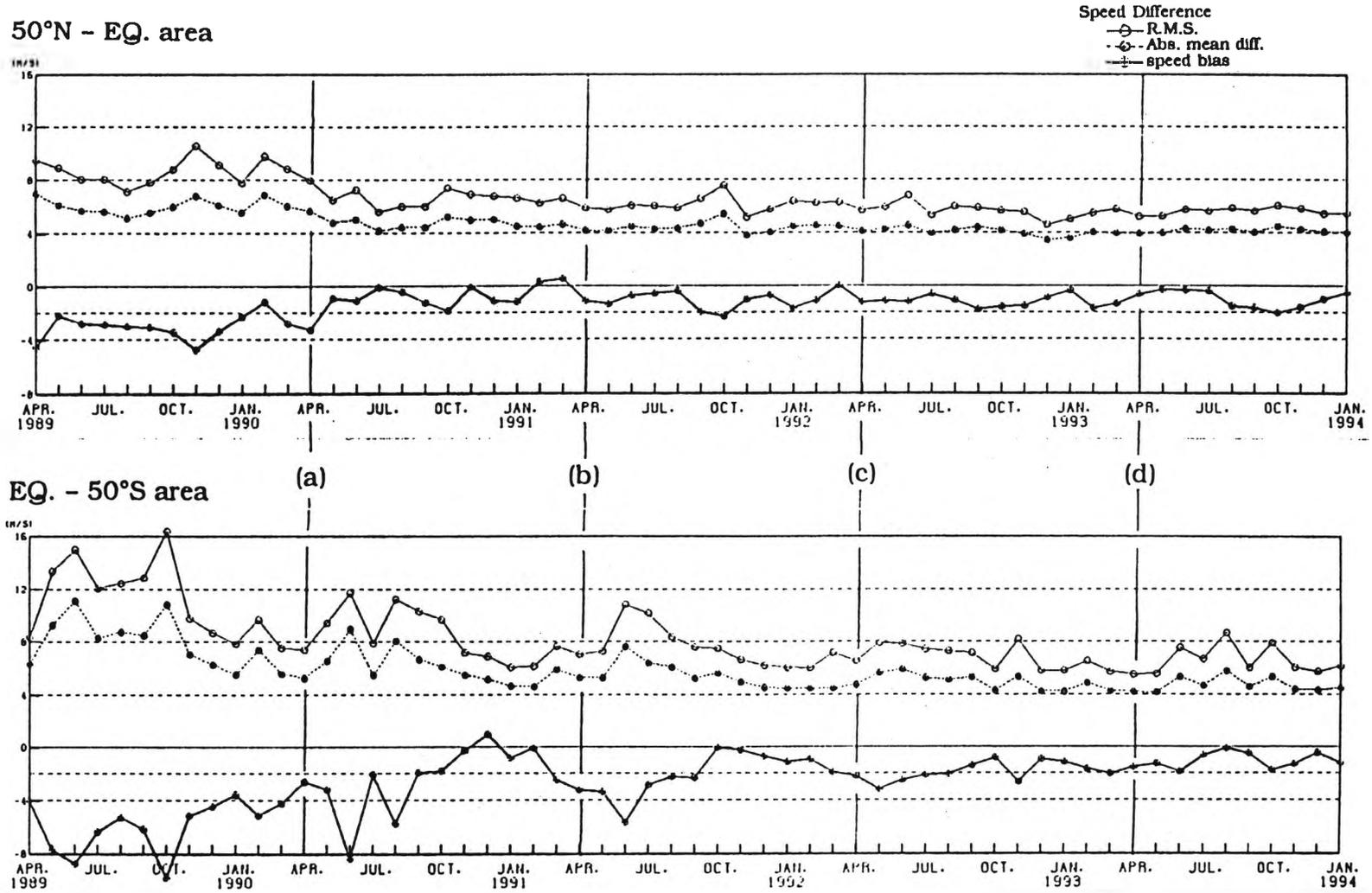


Fig. 2. Same as Fig. 1, but for speed difference.

On the Monitoring of Philippine Volcano Eruption

The Pinatubo Volcano is located at 15 N, 120 E, about 110km northwest of Manila City. After a silence of 610 years, the volcano had its first eruption on June 9, 1991. A few days later, with the vigorous roar, a series of violent eruptions of the Pinatubo Volcano were occurred in the afternoon (07UTC) of June 15. In the continuous eruptions, a large amount of lava, volcanic column with a height of 15000--20000 meters. In the satellite image, the eruption can be seen very clearly.

Figure 1 was a processed VIS image of GMS-4. The receiving time of the image was 07:34UTC of June 15, just half hour after the eruption. In the satellite images, the volcanic ash was shown as a director circle. The circle centered at the point of eruption occupied an area of about 14.5 hundred thousand square kilometers. On the right, the ash was spreading southwest and formed a rectangle of 280x260 square kilometers. The ash was reached a height of 10km of higher.

At the season, the upper troposphere (above 10km) over northern areas of South China Sea and Philippines was dominated by the north-east wind, so the ash should be moved southwest, and this was consistent with the satellite images. In Figure 2, the VIS image of the next day (June 16), the concentration of ash had decreased obviously, it was almost hardly identified in the image.

The analysing of satellite images indicated that the Pinatubo Volcano eruption had no obvious influence on the weather anomaly of China.

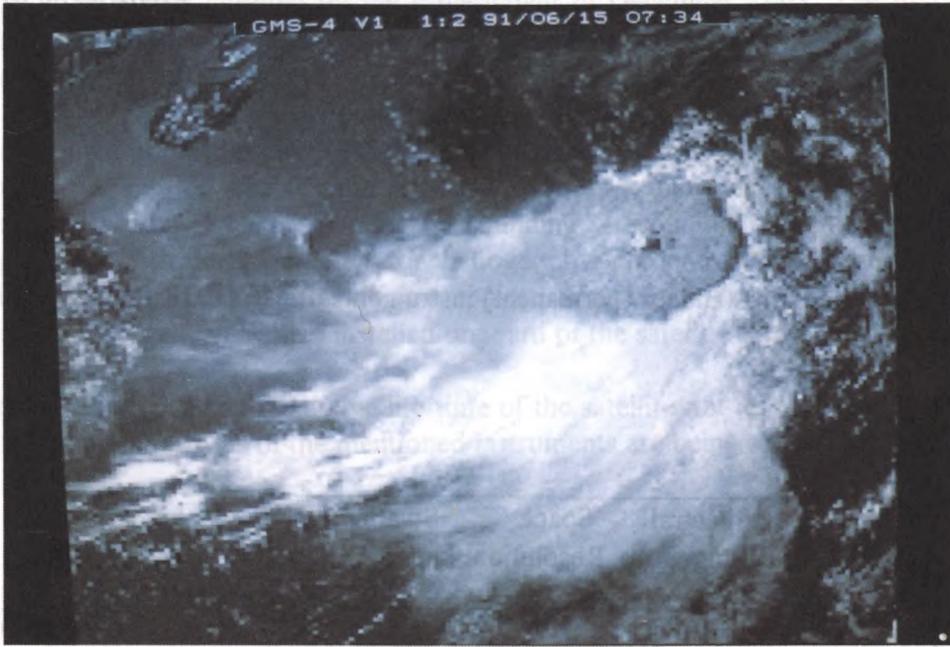


Fig.1 GMS-4 VIS Image
(91/06/15 07:34 UTC)

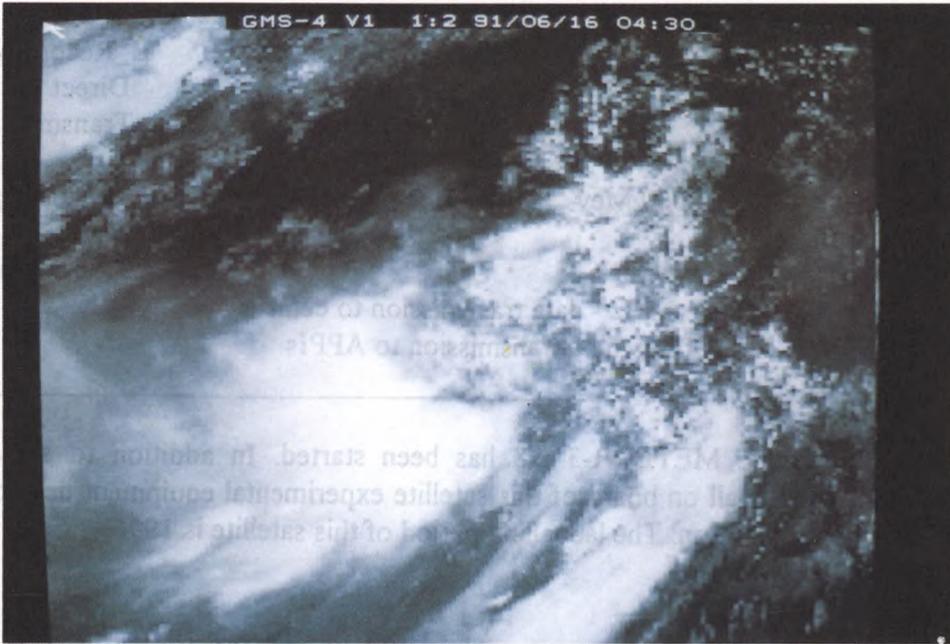


Fig.2 GMS-4 VIS Image
(91/06/16 04:30 UTC)

**Future Polar Orbiting Meteorological
 Satellite System (METEOR-3M)**

Series METEOR-3

The characteristics of onboard standard (permanent) instruments of METEOR-3 are given in table 1

Table 1

Instrument	Spectral Range, μm	Space Resolution, km	Swathwidth, km	Operation Mode
Scanning TV equipment with onboard data recorder for global coverage	0.5-0.8	0.7*1.4	3100	Recording, Direct Transmission
Scanning TV equipment for data transmission to APPIs	0.5-0.8	1*2	2600	Direct Transmission
Ten-channel scanning IR radiometer	10.5-12.5	3*3	3100	Recording, Direct Transmission
Radiometric complex	0.17-600 Mev	-	-	Recording, Direct Transmission
Radio link	466.5 MHz - data transmission to centres 137 MHz - data transmission to APPIs			

The manufacturing of satellite METEOR-3 N8 has been started. In addition to standard instruments it is planned to install on board of this satellite experimental equipment developed in frame of international cooperation. The launching period of this satellite is 1996.

Series METEOR-3M

The industrial enterprises have started developing new generation of polar orbiting

meteorological satellites METEOR-3M. These works are foreseen by the Federal Space Program of Russia adopted by the government in December 1993. The first satellite of this series is supposed to be launched in 1997. This satellite will be put into the orbit 900 - 950 km with inclination 82° - 83° .

It is planned to install onboard of this satellite the following instruments : - multichannel scanning device of visible and infrared range; - microwave scanning radiometers for atmospheric humidity and temperature sounding; - scanning radiation budget radiometer; - geophysical instrument complex for heliogeophysical parameters monitoring; - instrument complex for total ozone distribution mapping. A number of experimental instruments (home made and foreign) can be also installed onboard of the satellite.

It is planned to provide the active life time of the satellite not less than 3 years. At present the technical characteristics of the mentioned instruments are being specified.

The current stage of development of operational calibration scheme for GOMS infrared window channel

1. Introduction

The Hydrometeorological Centre of Russia (HMC) has made effort on the design of absolute calibration procedures for GOMS infrared window channel. The calibration procedure determines a relationship (linear) between the satellite measured digital counts and the physical radiances; it is necessary for the quantitative analysis of the GOMS image data.

The GOMS has on-board black body calibration facility but it can not be used for true absolute calibration due to the same reasons as for METEOSAT, GOES, GMS infrared channels. This device together with the procedure for obtaining the reference level by viewing space provide only monitoring of detector response and adjustment of gain factor. Thus some vicarious calibration is required as an alternative to in-flight calibration.

2. HMC calibration technique

Within the HMC the absolute calibration is foreseen utilizing two approaches : the first one (procedure 1) uses the comparison of satellite counts with calibrated radiometric data from similar channels aboard another satellites (METEOR-3, METEOSAT); the second one (procedure 2) employs relationship between measured counts and computed radiances.

The procedure 1 (called as cross-calibration method) is based on the similarity between GOMS IR window radiances and radiances measured in IR channels aboard another satellites and treated as external reference source. The data from METEOR-3 IR channel (10.5-12.5 μm , KLIMAT instrument) and METEOSAT-4 IR window channel are supposed to be used for the cross-calibration of GOMS IR data due to the fact that corresponding spectral response function are close to each other. The spectral response functions of mentioned channels are shown in Fig. 1.

The subsequent steps of cross-calibration method are as follows :

- derivation of regression relationship between radiances R_g from GOMS and reference radiances R_p from another satellite in the form

$$R_g = A * R_p + B \quad (1)$$

using synthetic (calculated) values for the same scene;

- the determination of calibration equation between radiances R_g and measured counts N , N_c (N_c =count at space view) in the form

$$R_g = D * (N - N_c) + E \quad (2)$$

The values of R_g are determined from (1) using collocated simultaneous and calibrated observations from METEOR-3 or METEOSAT as R_p .

The calibration procedure II consists of the following : selection of cloud free sea surface fragments and fragments with cold clouds and apriori known cloud top temperatures and attribution of related counts on the IR image; calculations of theoretical values of radiances R_p at the top of the atmosphere using fast radiative transfer code for selected fragments; formation of learning sample of pairs "calculated radiance - measured count"; determination of calibration coefficients in (2); control of calibration quality.

The fast radiative transfer code (LOWTRAN), spectral response function of IR channel (see fig. 1) and temperature and humidity profiles from HMC database as ancillary data are supposed to be used for radiance calculations.

3. Evaluation of calibration procedures

The testing of calibration procedure I has been performed partially (step 1) using simulated data. Radiances measured by IR radiometers installed at METEOR (KLIMAT), GOMS and METEOSAT satellites were simulated using LOWTRAN code. Calculations were made for the set of temperature and humidity climatic models over the region of 0-60 N, 0-90 E and for the viewing angles varied from 0 to 60 degrees. Here we have not considered possible variations in ozone and aerosol profiles. The radiance calculations and best least-square fitting give the resulting equations (1) presented at fig. 2, 3. The linear regression approach seems to work well since maximum deviations from the regression line do not exceed $0.7 \text{ mW/m}^2/\text{ster/sm-1}$ for both pairs.

For the validation of the procedure II the learning sample was collected on the basis of analysis of 7 METEOSAT IR image fragments (512 x 512 pixels) covering the Meditteranien Sea and North-West Atlantic for 7 days in December 1992. The total number of collocations (R_p , N) in learning sample is 44. Theoretical values of radiances R_p were computed with the radiative transfer model from Weinreb & Hill, (1980) using collocated temperature / humidity profiles from HMC database. The resulting calibration line (2) was compared with current ESOC calibration line. The maximum difference between radiances computed with both calibration equation does not exceed $0.7 \text{ mW}/(\text{m}^2 \cdot \text{sr} \cdot \text{cm})$ that is not more than 1% of sample mean value of measured radiances.

According to results of these experiments the procedures I, II can provide rather efficient tool for absolute calibration of GOMS IR window measurements.

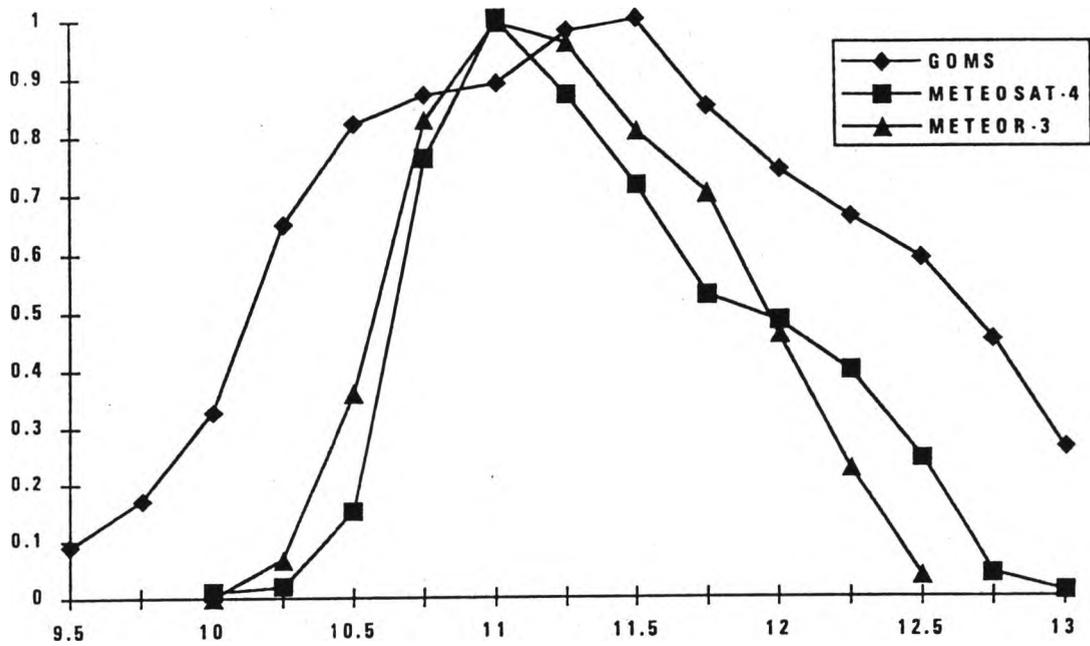


Fig.1. Spectral response functions of GOMS, METEOSAT-4 and METEOR-3 (KLIMAT) IR window channel

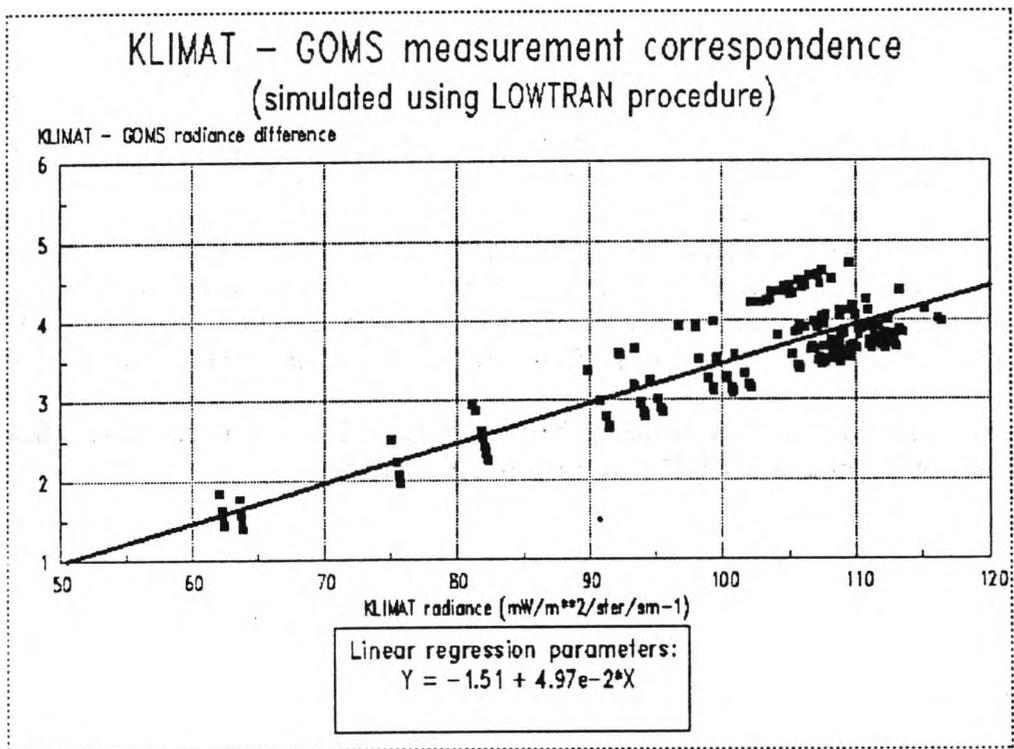


Fig.2.

METEOSAT - GOMS measurement correspondence (simulated using LOWTRAN procedure)

METEOSAT - GOMS radiance difference

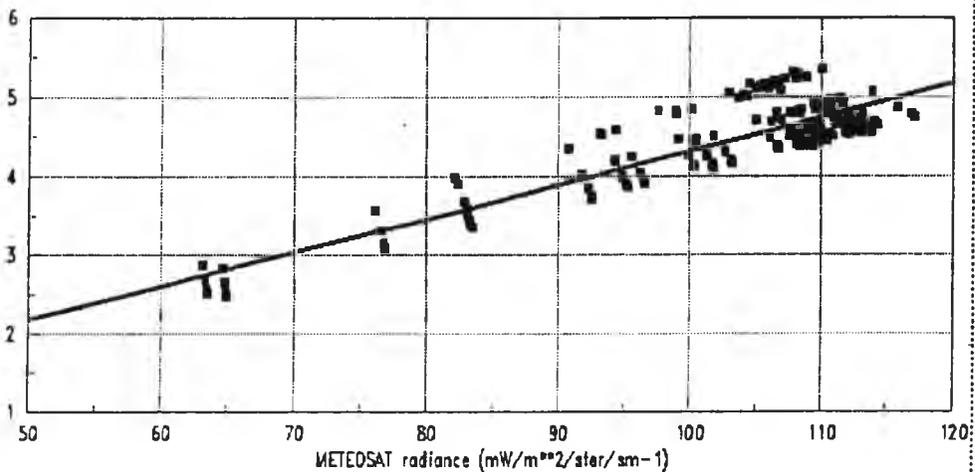


Fig.3.

Advanced Very High Resolution Radiometer(AVHRR) Pathfinder Calibration Activity

The NOAA/NASA AVHRR Pathfinder program has for one of its main objectives the reprocessing and rehabilitation of long-term records of AVHRR-derived environmental operational products such as aerosols, cloud morphology, sea surface temperature, and vegetation index for the Pathfinder period, 1981-present, for use in climate and global change research. It was recognized at the very inception of the Pathfinder program that state-of-the-science calibration algorithms should be applied to the raw AVHRR data in the reprocessing to ensure the quality and continuity of the long-term records spanning the operational lives of the AVHRRs on NOAA-7, -9, and -11 spacecraft. Towards this end, the AVHRR Pathfinder Calibration Working Group was formed in early 1991(Chair: C.R.N. Rao, NOAA/NESDIS), and charged with the responsibility for the development of the state-of-the-science calibration algorithms. The membership of the Calibration Working Group is drawn from NOAA, NASA, academia, and the private sector.

Using the southeastern part of the Libyan desert as a time-invariant calibration target, the in-orbit degradation rates of the visible(channel 1: $\approx 0.58-0.68\mu\text{m}$) and near infrared(channel 2: $\approx 0.72-1.1\mu\text{m}$) channels which have no on board calibration devices have been determined. The annual degradation rates for the two channels are respectively: 3.6% and 4.3%(NOAA-7); 5.9% and 3.5%(NOAA-9); and 1.2% and 2%(NOAA-11). Inter-satellite calibration linkages have been established to ensure continuity of record during the transition from one spacecraft to the next. Also, a user-friendly, radiance-based nonlinearity correction algorithm has been developed for the thermal infrared channels(channel 4: $\approx 10.3-11.3\mu\text{m}$; channel 5: $\approx 11.5-12.5\mu\text{m}$); this algorithm is applicable over the entire range of scene temperatures normally encountered by the AVHRR, and eliminates the need for the use of correction look-up tables. The above findings have already found application in the reprocessing of both operational and Pathfinder data sets, and have yielded encouraging results.

Two NOAA/NESDIS technical reports have been published, describing the activities of the AVHRR Pathfinder Calibration Working Group, and containing the recommendations of the Working Group to the user community. Additional details are found in four papers published in conference proceedings.

NOAA Technical Report NESDIS 73



INTERCOMPARISON OF THE OPERATIONAL CALIBRATION OF GOES-7 AND METEOSAT-3/4

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Ronald H. Brown, Secretary

National Oceanic and Atmospheric Administration
D. James Baker, Under Secretary

National Environmental Satellite, Data, and Information Service
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1. INTRODUCTION

Meteosat-3 is now positioned at 75 W and is calibrated operationally by using Meteosat-4 measurements as reference radiances in an area viewed by both satellites (de Waard et al., 1992). The Meteosat-3 calibration procedure is inherently noisy; recent work suggests methods to reduce the variability of the Meteosat-3 calibration coefficient. This note describes current operational procedures for calibrating GOES-7 and Meteosat-3/4 and reports on the intercomparison of radiance measurements from these geostationary satellites. The GOES-7 calibration, which occurs every spin (.6 seconds), was used to verify improvements in the Meteosat operational calibration procedures performed twice daily .

2. GOES-7 CALIBRATION

The VAS (Visible Infrared Spin Scan Radiometer Atmospheric Sounder) is a thirteen channel passive radiometer onboard the Geostationary Operational Environmental Satellite (4 through 7) which measures visible reflectances at 1 km resolution and infrared radiances in twelve spectral bands from 4 microns out to 14.5 microns at either 8 or 16 km resolution (depending on channel). For more information on the VAS, see Montgomery and Uccellini, 1985. The VAS detector responds to the combined radiation from the target and the telescope, or it responds to the radiation from an internal blackbody when a calibration shutter is inserted. The foreoptics components of the VAS telescope (mirrors, baffles, mirror masks) thus contribute to the background when the Earth or space is measured, but they do not contribute to calibration blackbody measurements. These foreoptics contributions to the background radiation are estimated with a radiative model and thermistor measurements of foreoptics temperatures (ranging between 15 and 35 C). If the blackbody had been external to the VAS, the determination of the VAS telescope contributions to the background radiation would have been unnecessary, and the calibration procedure would have been much simpler.

The VAS calibration involves measurements of radiation from space, an internal blackbody, and the target on earth (Menzel et al., 1981). The equations governing these measurements are

$$V_z = a [t R_z + (1 - t) R_v] + b, \quad (1)$$

$$V_{bb} = a R_{bb} + b, \quad (2)$$

$$V_e = a [t R_e + (1 - t) R_v] + b \quad (3)$$

where V is the output voltage of the detector, R is the input radiance, a is the responsivity of the detector, t is the transmittance of the VAS telescope, b is the detector offset voltage, z denotes space, bb denotes the internal blackbody, e denotes the target on earth, and v denotes the VAS telescope contributions to the background radiation. Space and blackbody looks occur every spin (0.6 seconds).

Assuming the input radiance from space is negligible, we write for the target radiance

$$R_e = \frac{V_e - V_z [R_{bb} - (1 - t) R_v]}{V_{bb} - V_z t} \quad (4)$$

R_v is determined by monitoring the temperatures of eight selected components of the telescope foreoptics. The transmittance t is calculated from the reflectivities, emissivities, and obscuration fractions of the various telescope components, that have been determined before launch; Menzel (1980) cites a value of 61% (within 2%).

The radiance emanating from a component of known temperature in a given band of known spectral response is determined by the normalized convolution of the Planck function and the spectral response function. Appendix A discusses a simple adjustment to the Planck function which takes the spectral bandwidth of a given channel into account.

The blackbody radiance is calculated from the measured temperature within the blackbody cone, T_{bb} , the emissivity of the shutter cavity, ϵ , and its temperature, T_{sc} , using the relation

$$R_{bb} = (1 - \epsilon) R(T_{bb}) + \epsilon R(T_{sc}). \quad (5)$$

The radiance of the VAS telescope has been modeled so that Eq (4) reads

$$R_e = \frac{V_e - V_z}{V_{bb} - V_z} (R(T_{bb}) + \sum_j C_j [R(T_{bb}) - R(T_j)]), \quad (6)$$

where the sum \sum_j runs over seven telescope foreoptics components that contribute appreciably to the background radiation, plus the shutter cavity with C_{sc} equal to $-\epsilon/t$. The term in the brackets () represents the equivalent blackbody radiance, had it been placed external to the telescope, which we denote by R_{ebb} . The C_j are constants determined from reflectivities, emissivities, and obscuration fractions and are constrained by the relation

$$\sum_j' C_j = \frac{(1 - t)}{t} \quad (7)$$

where the sum \sum_j' runs over the seven telescope foreoptics components, but does not include the shutter cavity.

The contributions of the foreoptics components to the measured radiance when viewing the earth are 39% of the total signal, when the earth and the telescope are roughly at the same temperature (between 15 and 35 C).

The calibration algorithm is implemented for each spectral band in the following way. The detector voltage, V_i , measured in response to incident radiation is adjusted with a cubic fit so that it accommodates small nonlinearities in the detector response. This adjusted response, X_i , is converted to a radiance value, R_i , by writing

$$R_i = \text{slope} * X_i - \text{intercept} \quad (8)$$

where i indicates space, blackbody, or earth. This linear relationship is calculated for every spin of the VAS using

$$\text{slope} = R_{\text{ebb}} / [X_{\text{bb}} - \min(X_{\text{zeast}}, X_{\text{zwest}})], \text{ and} \quad (9)$$

$$\text{intercept} = \text{slope} * \min(X_{\text{zeast}}, X_{\text{zwest}}). \quad (10)$$

The minimum of the adjusted space responses east and west of the earth, ($X_{\text{zeast}}, X_{\text{zwest}}$), is used to avoid influences of the sun or the moon. The radiance value for a given pixel is converted to a ten bit integer using a linear relationship (estimated prelaunch) that allows nominal scenes to activate nine of the available ten bits. All VAS instruments during their functioning days have been calibrated every spin as just described.

The conversion from radiance to brightness temperature for the nominal range of observed earth-atmosphere temperatures (200 C to 330 K) is easily performed with accuracy to better than .2% with adjusted Planck functions. Appendix A provides more details.

The nonlinearity correction implicit in Eq (8) and the calibration coefficients C_j from Eq (7) should be adjusted seasonally to accommodate the changing nominal temperature of the VAS telescope. Currently the summer coefficients are used year round. Using the summer values to calibrate the winter data introduces an offset of several tenths of a degree Centigrade (primarily in the longwave infrared window channel).

Diurnal trends in the calibration are tracked very well; measurements of presumed isothermal areas of the ocean remain constant within a few tenths of a degree Centigrade throughout the day. GOES-7 Multi-Spectral Image (MSI) calibration parameters for the IR window (band 8 at 11.2 μm) have been investigated for eclipse and non-eclipse days. During a non-eclipse day, the VAS foreoptics temperatures remain steady within a few degrees and the slope is constant within 0.1%, while the intercept is within 0.8%. During an eclipse day, some of the VAS foreoptics experience up to a 10 C temperature excursion and the slope remained constant within 1.5% and the intercept within 2.8%. On an eclipse day, using the 00 UTC slope and intercept values at 09 UTC would have caused a brightness temperature error of approximately 1 C (Schmit and Menzel, 1992b). The line-by-line VAS calibration algorithm compensates very well for changes in the foreoptics temperatures.

The VAS onboard GOES-7 has been used to construct a time series of average radiances (for 9 x 9 field of view areas) near the North Pole for three years beginning in late 1988. This analysis (Schmit and Menzel, 1992a) of mean radiances revealed that the mean summer radiance values nearly repeat from year to year. For example, channel 3 at 14.2 microns shows mean summer radiance peaks of 57.6, 57.1, and 57.7 mW/(m²-ster-cm⁻¹) for the summers of 1989, 1990 and 1991, respectively. This consistency of the VAS measurements indicate a long-term stability within .3 C.

3. METEOSAT-4 CALIBRATION

Meteosat is a geostationary satellite equipped with a three channel passive radiometer that measures visible reflectances and infrared radiances in spectral bands at 6.4 (water vapor, WV) and 11.5 (infrared window, IRW) microns. Sub-satellite spatial resolution is 2.5 km in the visible and 5.0 km in the infrared. For more information on the Meteosat see ESA, 1987. At the European Space Operations Centre (ESOC), calibration is performed with computed reference radiances performing the role of the blackbody in the VAS calibration. Both the IR and WV channels are operationally calibrated with radiances calculated from radiative transfer models.

For the infrared radiometer channels, the radiance R_{sat} may be associated with a measured count via a linear relationship:

$$R_{\text{sat}} = a (C - C_z) \quad (11)$$

where a is the calculated calibration coefficient, C the measured count and C_z the count when viewing space. The calibration coefficient is calculated from the relation

$$a = \frac{R_{\text{ref}} - R_z}{C_{\text{ref}} - C_z} \quad (12)$$

where R_{ref} is the radiance calculated from the radiative transfer model, R_z is the radiance from space assumed to be negligible, and C_{ref} and C_z are the corresponding counts detected by the Meteosat-4 radiometer.

The calibration establishes a functional relationship between the measured digital counts and the radiances. The calibration of the thermal infrared channels (IR window at 10.5 - 12.5 μm and WV at 5.7 - 7.1 μm) must be monitored continuously, since significant short term changes in radiometer response may occur due to aging, contamination, or heating cycles (Jones and Morgan, 1981).

Both the IR and the WV channels are calibrated operationally at ESOC using radiative transfer models and correlative data on temperature and humidity. Although calibration programs are run twice a day, the actual calibration coefficients are changed only when significant changes occur. The calibration data is disseminated to users along with the digital image data.

For the operational calibration of the IR channel at ESOC, measured counts of cloud free scenes over the ocean are associated with calculated radiances at the top of the atmosphere (Gaertner, 1988). The radiances are

computed with a radiative transfer code (Schmetz, 1986) from the sea surface temperature analysis from the National Meteorological Centre (NMC) in Washington and forecast profiles of the atmospheric temperature and humidity from the European Centre for Medium range Weather Forecast (ECMWF). The method provides consistent and precise measures of the IR calibration and is well suited for monitoring short term fluctuations. The absolute accuracy of the calibration is sensitive to cloud contamination of clear sky radiances (Gaertner, 1988 and 1989); careful identification of the clear sky scenes allows the operational calibration precision to be on the order of 1% (De Waard et al., 1992). The calibration coefficient, a , which is equivalent to the slope in the VAS calibration algorithm, changes by less than 0.5% between calibration events every twelve hours (about the same stability as found in the VAS slope).

For the water vapor channel, calibration coefficients are obtained from a linear regression of collocations between the satellite measured counts and radiances calculated with a radiative transfer model from conventional radiosonde profiles (Schmetz, 1989). Only radiosondes from clear or low cloud areas are considered for the calibration; the water vapor channel is not sensitive to low level clouds. Calibration coefficients are derived twice per day (1200 and 2400 UT) at ESOC. The WV calibration coefficient is steady to about 2.5% between calibration events; this variation is larger than one would expect from a spinning radiometer and is probably due to the variable quality of the upper tropospheric humidity measurements from radiosondes.

4. METEOSAT-3 CALIBRATION

The IR and WV calibrations for Meteosat-3 at 50 West are obtained twice per day indirectly via cross-calibration with Meteosat-4 at 0 longitude. Thus R_{ref} for Meteosat-3 in Eq (12) is determined from Meteosat-4 calibrated radiance measurements, rather than the model calculation of R_{ref} used for Meteosat-4. An area of 400 x 400 pixels is selected in simultaneous images from both satellites and a mean radiance is computed for Meteosat-4 using the operational calibration. The area for cross-calibration is selected half way between the two satellites. Azimuthal isotropy of the atmospheric water vapor over the selected area is assumed. A correction for the different spectral response functions is performed. The information on calibration is distributed to the user within the header of the disseminated digital image formats. The Meteosat-3 calibration coefficients vary between calibration events by 5.5% for IRW and by 6.3% for WV

5. GEOSTATIONARY SATELLITE COMPARISON RESULTS

Simultaneous collocated radiance measurements from different geostationary satellites were compared to indicate the effectiveness of the calibration procedures. Both infrared window and the water vapor channels were investigated. To mitigate the effects of atmospheric correction, radiance measurements at the equator in areas equally distant from either satellite were selected. Thus, GOES-7 (viewing from 111 W) and Meteosat-3 (viewing from 75 W) radiance measurements over an area centered at 93 W were compared; Meteosat-4 (viewing from 0 W on the Greenwich meridian) and Meteosat-3 radiance measurements over an area centered at 37.5 W were compared. The comparison area is enclosed by 5 degrees latitude and 3 degrees longitude centered on the equator. The radiance measurements were projected

into a common satellite view angle to assure similar cloud cover in the area and then averaged. Figure 1 shows the IRW brightness temperature comparisons at three hourly intervals for three days. The GOES-7 minus Meteosat-3 brightness temperature differences range from 2.3 to -1.2 and show considerable change after each Meteosat-3 calibration event (at 8 and 20 UTC). The problem lies in the variation in the Meteosat-3 calibration coefficient from one calibration event to another. The Meteosat-4 minus Meteosat-3 brightness temperature differences show similar behavior during the first four days, suggesting that GOES-7 and Meteosat-4 are in basic agreement; the departure on the last day could be due to extremely cloudy conditions in the calibration area.

6. IMPROVED CALIBRATION FOR METEOSAT-3

After further investigation, the Meteosat-3 calibration procedure was changed in the following way. First, the vicarious Meteosat-3 calibration via Meteosat-4 was adjusted so that the radiance measurements from both satellites were remapped into a geostationary projection at 37.5 W longitude. Inspection of scenes without adjusting for the different satellite view angles often showed different cloud amounts and hence different radiance measurements; without adjustment for the satellite view angles Meteosat-4 could not be used as a reference radiance measurement for Meteosat-3. Second, the calibration coefficient, a , was smoothed to mitigate the effects of abrupt changes. The smoothing algorithm uses the last ten calibration events to determine a gaussian distribution for the coefficients, then the last five coefficients are averaged with that gaussian weighting. More explicitly, the mean coefficient, a_m , and the standard deviation from that mean, σ_m , are calculated from the last ten calibration events. Then the smoothed calibration coefficient, a_s , is calculated from the weighted mean of the last five calibration events; thus

$$a_s = \frac{\sum_{j=1}^5 a_j G(a_j, a_m, \sigma_m)}{\sum_{j=1}^5 G(a_j, a_m, \sigma_m)}, \quad (13)$$

where G denotes the Gaussian distribution given by

$$G(a_j, a_m, \sigma_m) = \exp[-(a_j - a_m)^2 / (2 \sigma_m^2)]. \quad (14)$$

This smoothing allows the coefficients to indicate real changes that occur over several days during eclipse, but still maintain adequate smoothing in non-eclipse times.

Figure 2 shows the coefficients for days 169 to 182 in 1993 using the new algorithm (view adjusted radiances and coefficient smoothing over the last five calibration events) in comparison to the original coefficients. The new coefficients vary by 0.3% at the most between calibration events (in contrast to 5.5% for the original algorithm); slow trends are captured but noise is minimized. Some of this remaining variation may be due to the differing scenes (mostly cloudy or mostly clear) that are used in the Meteosat-4 reference measurements; the uncompensated 1% nonlinearity in the Meteosat-3 IRW detector response will bring about larger calibration coefficients for clear (warm) scenes than for cloudy (cold) scenes.

Figure 3 shows the GOES-7 minus Meteosat-3 brightness temperature differences for days 175 through 178 in 1993, using the original and the new calibration procedures. The original procedure shows a range of 2.0 C to -1.2 C (similar to the data of days 146 to 149), while the new procedure reduces the range to 1.5 C to -0.1 C (mean difference is .6 C). The new calibration procedure has halved the disagreement between the GOES-7 and Meteosat-3 sensors.

Some of remaining difference between the GOES-7 and Meteosat-3 brightness temperature values can be ascribed to the different atmospheric absorption caused by the different IRW spectral response functions of the two sensors. Figure 4 shows the differing brightness temperatures that are measured by GOES-7, Meteosat-3, and Meteosat-4 for a tropical standard atmosphere (4 cm column moisture in the atmosphere). For a viewing angle of about 20 degrees, GOES-7 is about .5 C warmer than Meteosat-3, in very good agreement with the .6 C mean difference in the observed brightness temperatures for days 175 through 178.

7. COMPARISON WITH POLAR ORBITING SATELLITES

The geostationary satellites can only be calibrated directly with respect to one another if their earth views have some overlap. However the polar orbiting High resolution Infrared Radiation Sounder (HIRS) offers a fixed reference for all of the geostationary satellites. The nineteen channel HIRS has both an infrared window and a water vapor channel (for more information on the HIRS, see Smith et al., 1979). An example of polar and geostationary radiance comparison is presented here.

The GOES and HIRS data are compared with histograms of brightness temperatures of similar spectral channels from the two sensors for an area near the GOES sub-satellite point (Schmit and Herman, 1992). This method minimizes viewing angle differences and the need for high accuracy navigation. Figure 5 shows the two histograms over the same region on July 1, 1991 for both the GOES-7 VAS and NOAA-11 HIRS IRW brightness temperatures, respectively. Both capture the peaks associated with the low cloud and the clear ocean. Sensor resolution differences account for some of the discrepancies. The mean brightness temperature difference is smaller than 0.5 C. The collocation in time was less than 30 minutes.

Favorable comparisons between Meteosat-3 and NOAA-12 IRW window data have also been found. Mean values were within 1 C. Thus the polar orbiter data are also indicating good consistency of GOES-7 and Meteosat-3 radiances.

8. CONCLUSIONS

As expected, improved performance of the Meteosat-3 calibration is possible when the calibration procedure is adjusted so that intercalibration with Meteosat-4 radiances is done at the same satellite view angle and the calibration coefficients are smoothed over the past five calibration events. This paper shows GOES-7 minus Meteosat-3 brightness temperature differences are 0.6 C on the average when viewing the same area at the equator; scatter about this mean is 0.6 C. Spectral differences in the two infrared windows would account for 0.5 C of this difference. This suggests several recommendations.

* For the operational Meteosat-3 vicarious calibration using Meteosat-4 reference radiances, the satellite data should be navigated to the same satellite view angle (preferably one exactly between the two satellites, eg. 37.5 W for the current positions of Meteosat-3 at 75 W and Meteosat-4 at 0 W).

* The calibration coefficients for both Meteosat-3 and Meteosat-4 should be smoothed to alleviate the effects of scene differences and detector non-linearity; a gaussian distribution from the last ten calibration events has been used to determine a weighted mean of the last five calibration coefficients and has demonstrated greatly improved results.

* The calibration coefficient for both Meteosat-3 and Meteosat-4 should be changed at most once per day (close to 00 UT) so that diurnal changes in the measured brightness temperatures better reflect changes in the earth-atmosphere system.

On August 11, 1993, the ESOC adopted these recommendations and their operational calibration of Meteosat-3 and -4 has been changed accordingly.

APPENDIX A. ADJUSTED PLANCK FUNCTIONS

The Planck function provides a means to determine monochromatic radiance as a function of temperature for a given wavenumber (or wavelength). To accommodate the spectral bandwidth of the satellite sensor measurements, the wavenumber is chosen to be the median value, ν_m , in the spectral response function, and the temperature, T , in the Planck function is adjusted to

$$tc1 + tc2 * T \quad (A1)$$

where $tc1$ and $tc2$ are determined in a least squares fit over a temperature range of 200 to 330 K. Thus the function becomes

$$B(\nu_m, T) = c1 * \nu_m^{**3} / [\exp(c2 * \nu_m / (tc1 + tc2 * T)) - 1] \quad (A2)$$

where $c1 = 1.191066 \text{ E-5 mW/m}^2/\text{ster/cm-4}$ and $c2 = 1.43883 \text{ deg C / cm-1}$. The following Table indicates the values for GOES-7, Meteosat-3, Meteosat-4, and Meteosat-5 IRW and WV channels.

Table: Coefficients for Adjusted Planck function calculation of temperature and radiance for infrared window and water vapor channels. GOES-7 is indicated by G-7 and Meteosat-3/4/5 is indicated by M-3/4/5.

Channel	ν_m	$tc1$	$tc2$
G-7 IRW	894.5	0.3408	.9973
G-7 WV	1488.0	0.6448	.9977
M-3 IRW	876.0	0.9065	.9967
M-3 WV	1549.2	4.3185	.9903
M-4 IRW	882.4	0.8275	.9870
M-4 WV	1601.1	3.2265	.9927
M-5 IRW	883.0	0.9613	.9966
M-5 WV	1612.2	3.5381	.9920

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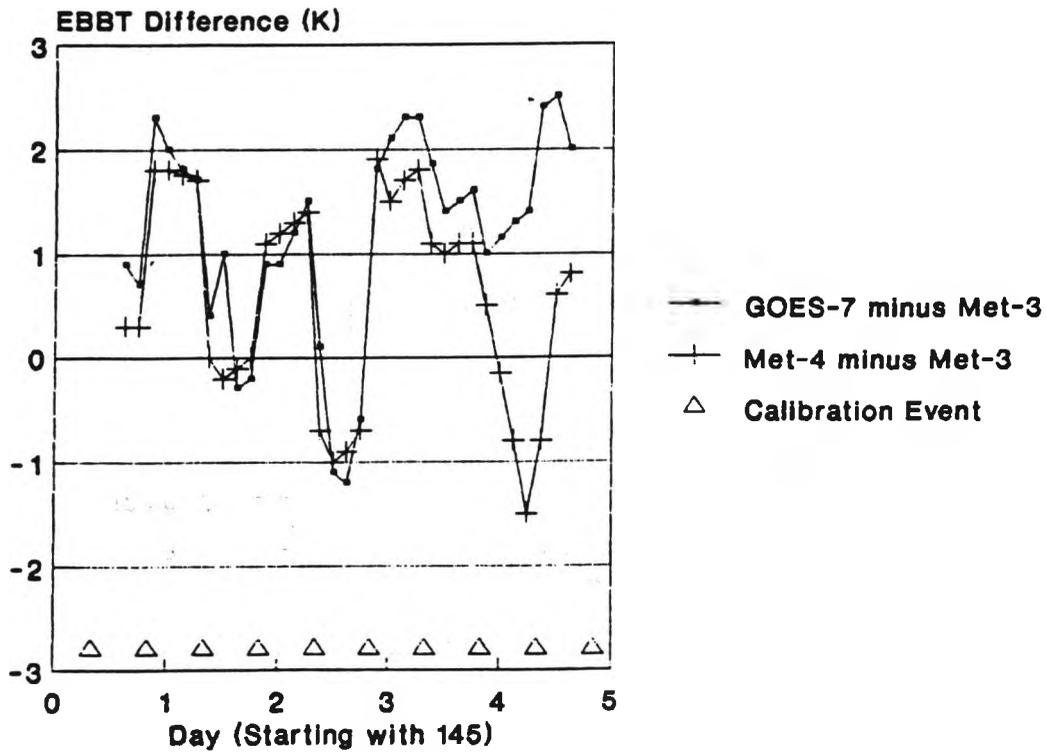


Figure 1. Infrared window brightness temperature (EBBT) differences in the measured GOES-7 minus Meteosat-3 radiances as well as the Meteosat-4 minus Meteosat-3 radiances for days 145 to 149 in 1993 at three hour intervals. The 12 hourly Meteosat-3 calibration events are indicated at the bottom. Calibration is performed using the original algorithm.

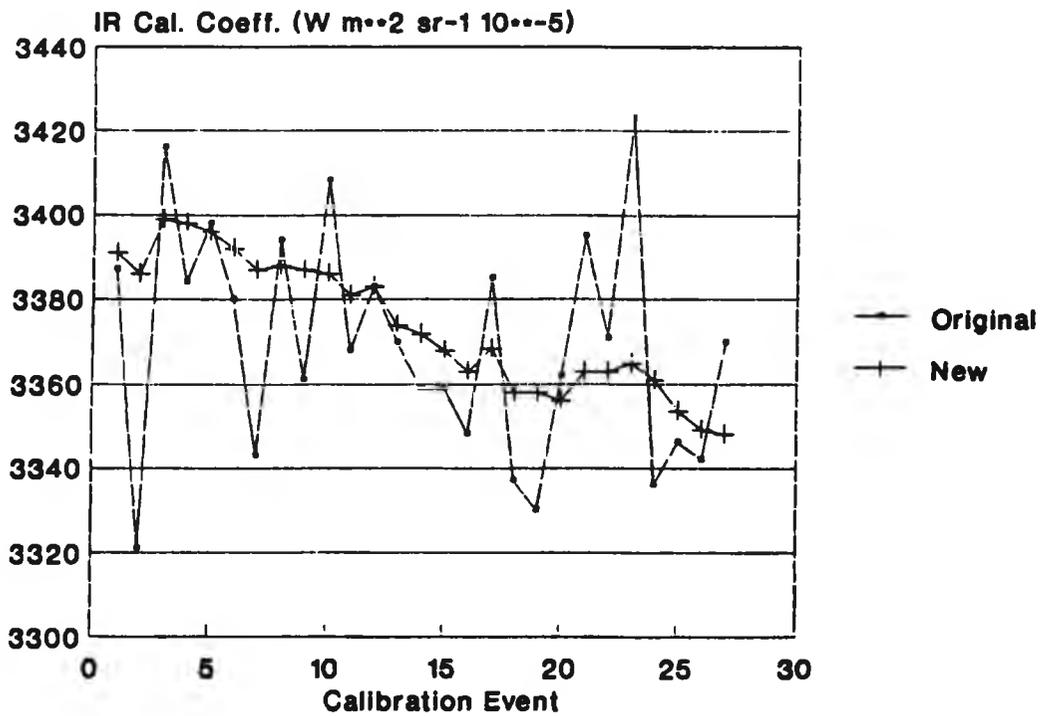


Figure 2. Meteosat-3 calibration coefficients evaluated twice daily for days 169 to 182 in 1993. Results from the original algorithm and the new algorithm are shown.

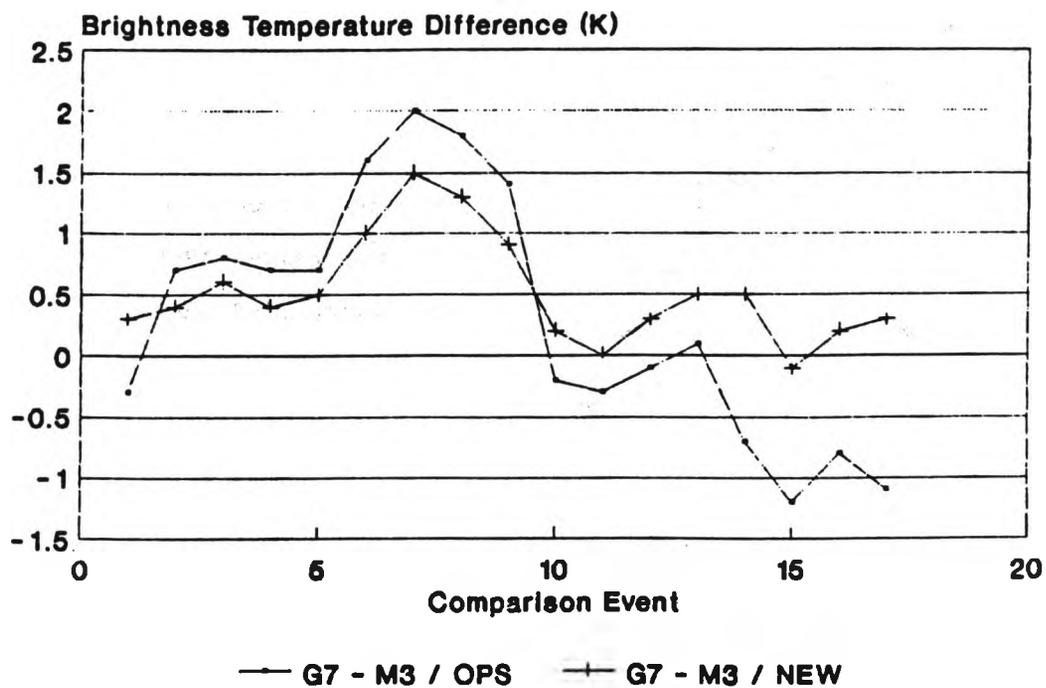


Figure 3. Brightness temperature differences in the measured GOES-7 minus Meteosat-3 infrared window radiances using the original and the new calibration algorithms for days 175 to 178 in 1993. The comparisons occurred at three hour intervals.

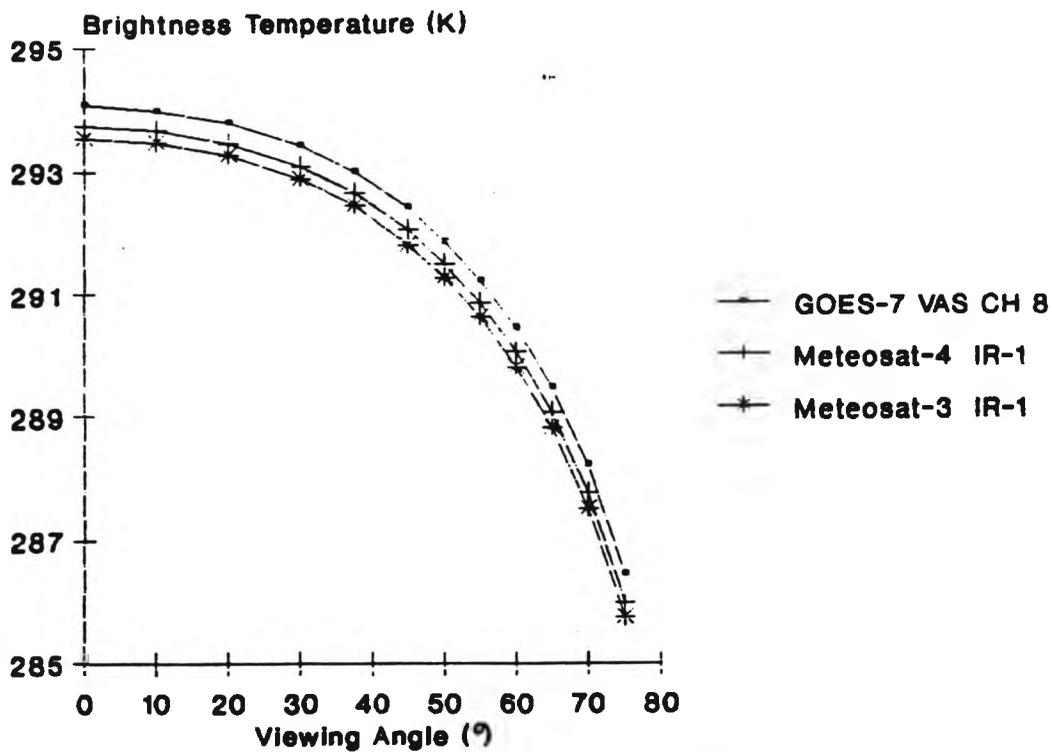


Figure 4. Brightness temperatures measured by GOES-7, Meteosat-3, and Meteosat-4 for a tropical standard atmosphere as a function of satellite viewing angle. Differences are due to the different spectral response functions of the sensors.

SATELLITE SUPPORT TO THE GLOBAL OCEAN OBSERVING SYSTEM¹

ABSTRACT

The international oceanic satellites offer a unique opportunity for numerous applications of remotely sensed data for marine meteorology and oceanography. In addition to the NOAA-Series of operational satellites, this paper will review the following polar-orbiting sensors and satellites and their contributions to oceanic monitoring that are or soon will be operating in this decade:

FSU Cosmos Series	USA/France TOPEX/Poseidon
USA DMSP Series	USA SeaWiFS
ESA ERS Series	Canada Radarsat
Japan MOS Series	Japan ADEOS
USA Geosat Follow-On	USA/Japan TRMM
Japan ERS-1	ESA EOS/POEM
USA EOS	Japan EOS

The merging of satellite observations, high-performance computers, and improved oceanic and marine meteorological models offers the first real opportunity to have a global ocean observing system. The World Meteorological Organization (WMO) and the Intergovernmental Oceanographic Commission (IOC) have seized upon this opportunity of merging technologies to go forward with formal planning for a Global Ocean Observing System (GOOS). Satellites make it possible for GOOS to be truly global in extent, improved surface programs offer the opportunity for high-quality data to be available for the computer models, and high-speed computers permit the models to be run in a useful timeframe. These combined capabilities allow both operational and research oceanic and climate needs to be met. Satisfying research needs takes on important new dimensions if the understanding of ocean climate and the long-term coupling of the ocean and atmosphere are to be goals of GOOS support to the Global Climate Observing System.

INTRODUCTION

The overall goals and perspectives on the Global Ocean Observing System (GOOS) is described by Baker (1991). The international oceanic satellites include important sensors needed to provide specific information to GOOS. The application of these sensors to marine meteorology and oceanography and the development of improved international cooperation are paving the way toward the establishment of the satellite component of the GOOS. The sensors of primary interest to GOOS include scatterometers, altimeters, ocean color scanners, synthetic aperture radars, and infrared and microwave radiometers. This working paper emphasizes the first four classes of sensors, since they are the new sensors coming online in the 1990s. These sensors fly on polar-orbiting satellites cited in the abstract and provide the needed global coverage.

¹Adapted from papers presented by John W. Sherman, III, presented at the IOC/WMO Technical Conference on Space-based Ocean Observations, Bergen, Norway, 5-10 September, 1993; and at the Pacific Ocean Remote Sensing Conference (PORSEC); 1-4 March 1994, Melbourne, Australia.

Because these sensors are becoming available now, the satellite component of the GOOS concept is not something that must wait for the future. Further, the notion that only the satellite-operating nations can participate in GOOS fails to recognize the importance of the surface data needed to complete the temporal coverage and validation of the many satellite sensors. The GOOS program needs all nations as participants to make it a strong, viable program that supports local, regional, and global problems in a synoptic manner.

THE SATELLITE DATA-ACQUISITION SYSTEM

To commit to a GOOS concept requires that the oceanic information be available on a routine basis for a long period of time. While no single nation can make such a commitment for flying these sensors on a routine, continuing basis, the ensemble of the sensors flown by all nations does provide long-term capability. The collective commitment by the world's space agencies to address the needs of the oceanic and marine meteorological communities provides the needed continuity for GOOS. Figure 1 illustrates this for scatterometers, altimeters, synthetic aperture radars, and ocean color scanners.

Further, these example sensors are nearly all-weather except for those devoted to the measurement of ocean color. Ocean color is included because it will significantly expand the satellite contributions to the understanding of the biological and physical coupling within the ocean. It will further serve as a new sensor to track ocean currents, eddies, and many of the features seen in the traditional measurements of ocean color. In addition, once the ocean color sensor data become available, the biological oceanic community can fully participate in satellite Earth observations.

THE GLOBAL OCEAN OBSERVING SYSTEM

GOOS is in itself a product of the thinking of a number of international groups, with the primary leadership belonging to the IOC. Presently, GOOS is co-sponsored by IOC, WMO, the United Nations Environmental Program (UNEP), and the International Council of Scientific Unions (ICSU). GOOS is expected to be an operational program modeled after the World Weather Watch (WWW). The details of the planning strategy for GOOS is well documented and will not be dealt with in depth in this paper (Baker, 1991; IOC 1993).

Several essential parts of GOOS are described here to demonstrate the satellite interfaces with and contributions to GOOS. There are five "application modules" agreed to internationally. These are:

<u>Module</u>	<u>Abbreviated Title for This Paper</u>
• Climate Monitoring, Assessment, and Prediction	Climate Change
• Monitoring and Assessment of Marine Living Resources	Living Marine Resources
• Monitoring of the Coastal Zone Environ. and Its Changes	Coastal Zone Management
• Assessment and Prediction of the Health of the Ocean	Health of the Ocean
• Marine Met. and Oceanographic Operational Services	Marine Weather & Services

The basic sciences involved in supporting GOOS are physical, chemical, and biological. However, because of the importance of computers and the models being developed, it is also essential to consider that the computer sciences are an inherent part of the GOOS science elements.

The observational components of GOOS can be regarded as consisting of four major components, which are:

- Satellite Observation
- Numerical Modeling
- *In Situ* Observations
- Data Exchange and Management

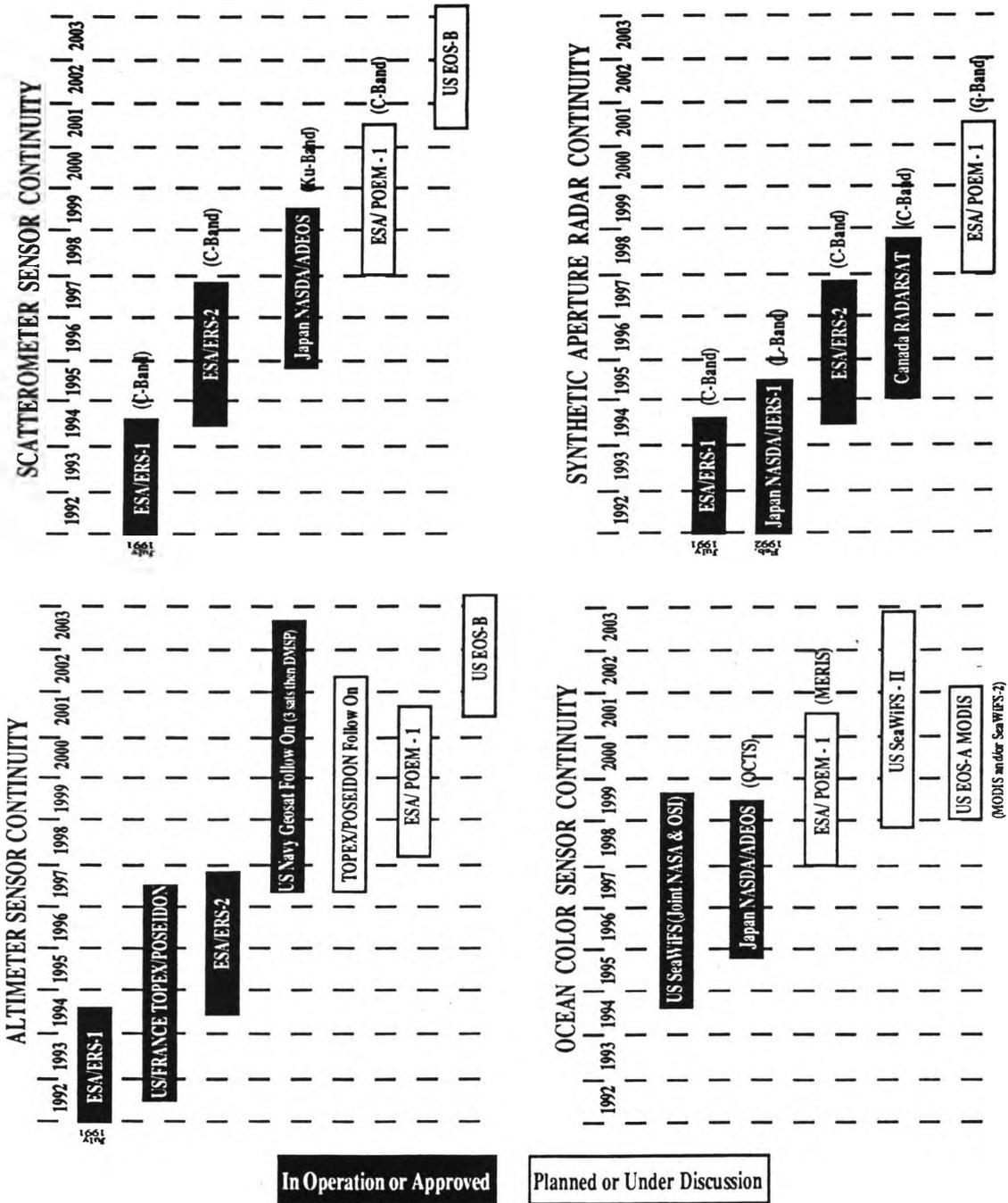


Figure 1 - Examples of satellite oceanic sensors in operation or approved for operation and planned or under discussion for oceanographic research or marine operations

It might be argued that satellite and *in situ* observations should be combined into one component of GOOS. However, because of the great differences in satellite observation methods and those associated with *in situ* observations, it is convenient to keep them separate. Further, it enables each nation, individual agency, or the participating scientist to define and understand their role in GOOS. It must be recognized that if the data are to be of sufficient quality to improve both Marine Weather and Services and Climate Change related observations, then very high-quality *in situ* data must be used to validate the satellite data.

Numerical modeling directly converts data into useful information for the modules of GOOS. Similarly, the exchange of data, both in near-real-time and retrospectively, will require expanded distribution and information management systems. To fulfill the requirements of the GOOS modules, long-term data records require efficient and secure data storage mechanisms. In order to observe and understand Earth processes, the modeling and data management aspects become an inherent part of the observing system. Historical data records from ice cores, tree rings, etc., permit the observation of Earth conditions in bygone years.

Taking advantage of these elements, it is possible to construct an overview diagram of the GOOS concept. Figure 2 shows how the GOOS modules, scientific elements, and observational components may be brought together. There may be other approaches but this diagram has been evolving and is complementary to the many ongoing international programs.

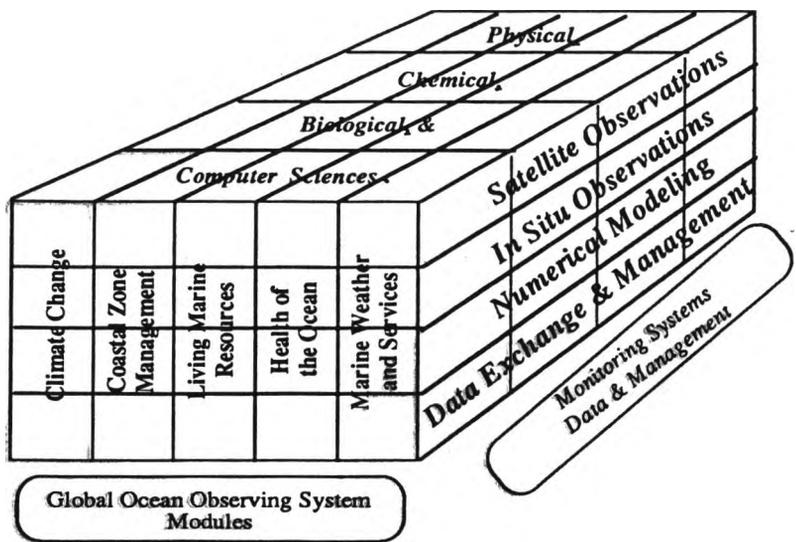


Figure 2 - The GOOS concept for satellites: GOOS modules, scientific elements, and observational components

The nomenclature in Figure 2 is a convenient mechanism to illustrate the GOOS concept. The GOOS modules may be different for each program and participant. The following is given as an example only:

GOOS Application Module

- Climate Change

Potential Program

- El Niño/Southern Oscillation Prediction
- Potential Global Warming
- Interdecadal Variability

GOOS Application Module (Continued)

Potential Program (Continued)

- | | |
|---|---|
| <ul style="list-style-type: none"> • Coastal Zone Management | Storm Surge
Sea Level Rise
Ecosystems
Productivity |
| <ul style="list-style-type: none"> • Living Marine Resources | Ecosystem Conditions
Fisheries Year-class Prediction
Transport Mechanisms |
| <ul style="list-style-type: none"> • Health of the Ocean | Aquatic Toxins
Eutrophication
Pollution Impacts |
| <ul style="list-style-type: none"> • Marine Weather and Services | Marine Forecasts and Warnings
Search and Rescue |

This listing is limited. Consider the GOOS Module for Marine Weather and Services. This Module is shown as a shaded feature in Figure 3.

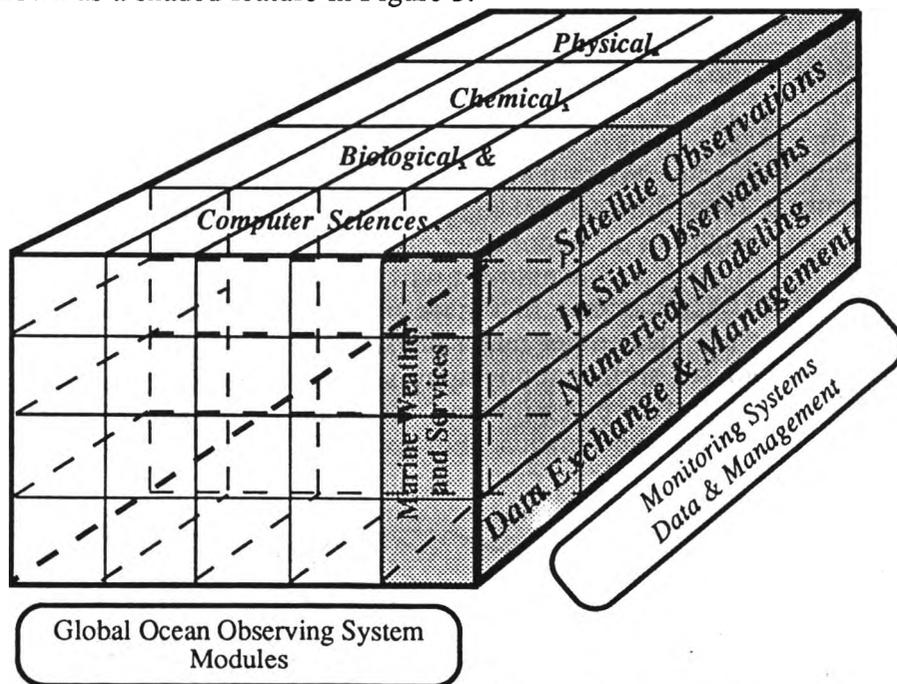
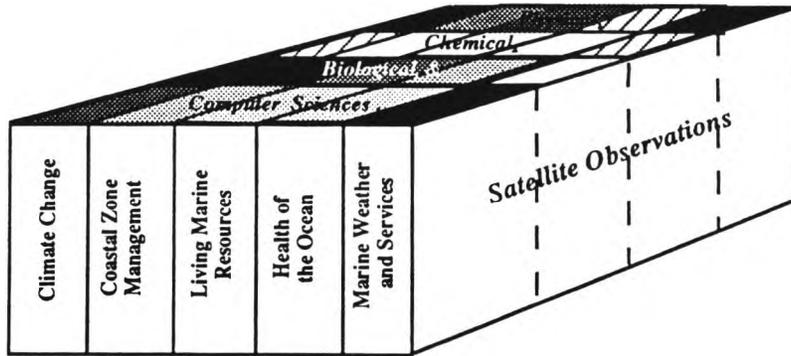


Figure 3 - GOOS marine weather module

It is doubtful that there may be any element in the matrix for the Chemical Element and the Satellite Observation Component, other than the possible transport of chemicals which must include data from sources in addition to satellites. Modeling of the wind and current fields, as updated by satellite data, may be the only satellite contribution to the Chemical Element.

If the Satellite Observation Component is isolated, then those activities directly related to satellites can be considered. Figure 4 is a diagram of direct satellite interface with the GOOS Modules. The shadings are the personal assessment of the author. The shadings are subjective and require consensus within scientific, agencies', and national programs. Even within international

programs, which include the Tropical Oceans and Global Atmosphere (TOGA) program, the World Ocean Circulation Experiment (WOCE), the Global Ocean Flux Study, etc., the priorities for satellite data can vary. However, realistic assessments of the individual activities must be addressed by the GOOS Modules on the basis of their need for satellite data. This modular approach is a convenient mechanism to accommodate all activities planned by GOOS developers.



Mandatory
 Essential
 Major Support
 Minor Support
 No Support

Figure 4 - GOOS modules for satellite environmental-data acquisition

The satellite observing component can be further subdivided into the sensor systems cited in Figure 1. This is demonstrated in Figure 5 for the altimeter, scatterometer, ocean color scanner, and synthetic aperture radar. In this illustration the Physical Science Element has been detached from the other science elements. When the Physical Science Element is examined by itself, it once again becomes a three-dimensional matrix as is shown in Figure 6 with additional subsience elements. A weighting of importance could be assigned to each GOOS Module in either Figure 5 or 6, but such an assessment will always vary depending on the specific application and user of that application. In Figure 6 only four basic physical parameters are given for simplicity. There are many other major physical parameters of importance that are not included. These range from sea surface topography and mean sea level, to ocean currents and circulation, and on further to surface precipitation. It should be recognized that in Figure 6 all sensors do not address all science subelements. For example, the altimeter will not measure sea surface temperature, so that 'box' would be empty for that component of the science subelement.

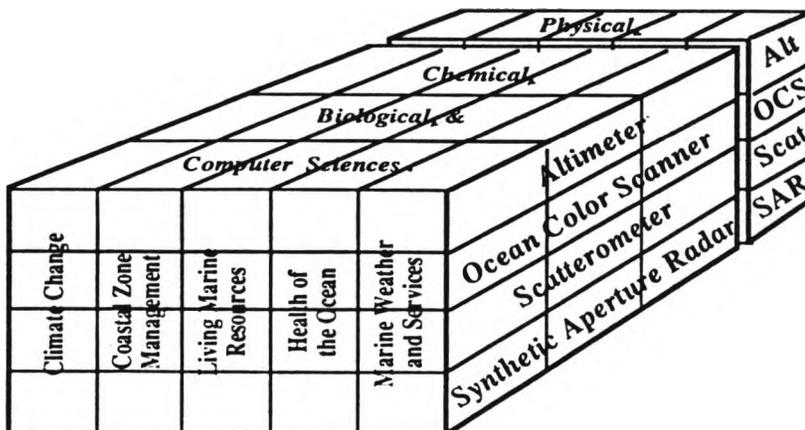


Figure 5 - Individual oceanic sensor components in support of the GOOS modules (The physical element is shown split from the other science elements.)

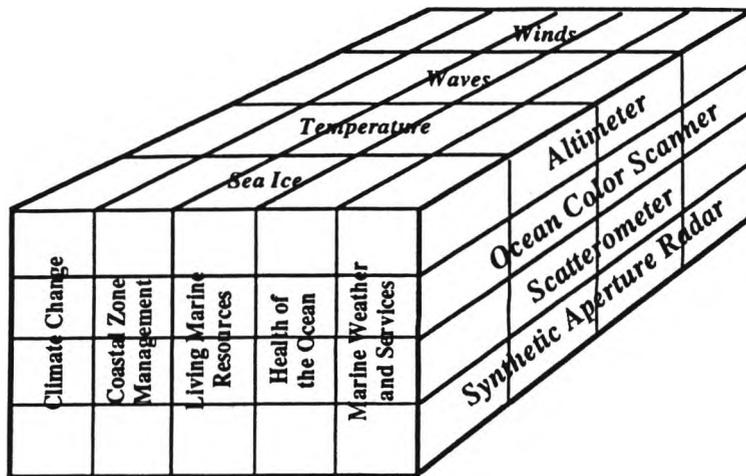


Figure 6 - Individual sensor matrix applied to physical oceanographic measurements

GOOS AND THE GLOBAL CLIMATE OBSERVING SYSTEM

There is a need to develop a climate observing system, and a joint effort by WMO, UNESCO, UNEP, and the International Council of Scientific Unions (ICSU) has established an international effort for the Global Climate Observing System (GCOS). It has been agreed that the oceanic component of GCOS is the climate module of GOOS, and that GCOS will have a major role in defining the Climate Module of GOOS. The formal Climate Modules included in GCOS (1993) are eight-fold:

- Global Atmosphere Watch (GAW)
- Integrated Global Ocean Services System (IGOSS)
- Global Sea Level Observing System (GLOSS)
- Global Environmental Monitoring System (GEMS)

- Hydrosphere Measurements
- Cryosphere Measurements
- Research Programs
- Data Systems

On an informal basis, the GCOS Concept can be structured as shown in Figure 7.

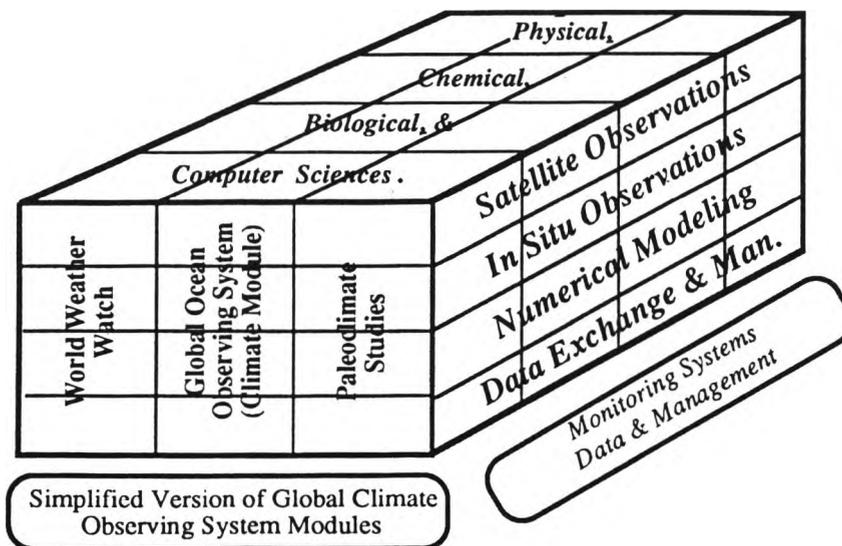


Figure 7 - The modules of the Global Climate Observing System

THE FOUNDATION TO GOOS AND GCOS

It is with considerable forethought that Data Exchange and Management appear as the bottom tier in Figures 2, 3, and 7. It is not that data exchange and management are last in priority but that data acquisition and its management are the foundation to support these global monitoring programs, be they for the ocean or the climate. Data considerations are too large to be simply the cornerstone to global environmental monitoring. Data are the foundation. If global data sets are not openly and freely available for marine, weather, or climate global models, then the acquisition of satellite data will have limited benefits.

A major concern of the international Committee on Earth Observations Satellites (CEOS 1992) is developing a broad policy on open exchange of satellite-derived data. They have stated:

“CEOS members endorsed the following principles relating to data exchange in support of global change/climate and environmental research and agree to work toward implementing them to the fullest extent possible....

4. Maximizing the use of satellite data is a fundamental objective. An exchange/sharing mechanism among CEOS members is an essential first step to maximize use....”

This concern is shared by the IOC (1993) who adopted a data management policy:

“The overall purpose of this policy statement is to facilitate full and open access to quality ocean data for global ocean research programs. The Global Ocean Program to be carried out under GOOS requires an early and continuing commitment to the establishment, maintenance, validation, description, accessibility and distribution of high-quality long-term data sets....

(i) Full and open sharing of a wide spectrum of global international data sets for all ocean programs is a fundamental objective....”

It appears that the broad national and international programs in satellite observations of the Earth's environment are causing the current data policies to be reconsidered by many nations. The general free and open access to the real-time data, such as that provided by AVHRR, should be continued if programs like GOOS and GCOS are to be successful.

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ITWG REPORT TO CGMS

From Report on Satellite Sounding, submitted to the WMO
in April 1994 by Drs. J. Eyre, P. Menzel, and J. Le Marshall

1. Purpose

This report summarizes recent developments in the application of data from operational satellite sounding instruments, principally the TOVS (TIROS Operational Vertical Sounder) instruments on the TIROS-N/NOAA series of polar orbiting satellites, and it records some activities relevant to the implementation of improved satellite sounding systems on future satellites. It lists areas of recommendation and action for the consideration of the CGMS.

2. Background

The ITWG is convened as a sub-group of the Radiation Commission of the International Association of Meteorology and Atmospheric Physics (IAMAP). ITWG continues to organize International TOVS Study Conferences (ITSCs) which have met every 18-24 months since 1983 and are attended by about 100 active members representing over 25 countries. Through this forum, operational and research users of TOVS data from the NOAA series of polar orbiting satellites have exchanged information on methods for extracting information from TOVS data on the atmospheric temperature/moisture field and on the impact of these data in numerical weather prediction and in climate studies. They have also prepared recommendations to guide the directions of future research and to influence relevant programmes of WMO and other agencies. Reports on the activities of the ITSCs have appeared in the Bulletin of the American Meteorological Society (Menzel, 1987; Lynch et al., 1989; Menzel and Chedin, 1990; Menzel and Chedin, 1991).

Considerable effort has been given to expanding the TOVS user community through distribution of processing software. Two processing packages have been distributed widely: the Improved Initialization Inversion (3I), through the efforts of the Laboratoire de Meteorologie Dynamique (LMD), and the International TOVS Processing Package, through the efforts of the Cooperative Institute for Meteorological Satellite Studies (CIMSS), have been implemented and are used at about 100 locations. Documentation, bench mark data processing sets, and user familiarization programs accompany these packages. While

these are research packages, they have been adapted to operational use at several centres. Ongoing efforts are currently supported by user donations.

3. Recent advances

ITSC-VII was held in Igls, Austria, from 10-16 February 1993. A "Report on the Seventh International TOVS Study Conference" presents the scientific exchanges and outcomes of the meeting. A summary of this report is given in Appendix A. A companion document entitled "The Technical Proceedings of ITSC-VII" contains the complete text of the scientific presentations. In addition, the Conference endorsed the report entitled "ITWG: a Strategy for the 1990s". These documents reflect the conduct of a highly successful meeting in Igls; an active and mature community of TOVS data users now exists, and considerable progress and positive results were reported in a number of areas, including:

- The use of TOVS data in climate studies.

Significant progress was reported by a number of institutions on the application of TOVS data in climate research, and in particular in studies of the inter-annual variability of temperature, humidity and cloud cover. Advances have also been made in the extraction of total column ozone information from TOVS data.

- The use of TOVS data in numerical weather prediction (NWP).

TOVS data have been shown to have consistent positive impact on NWP in both hemispheres. In the Northern Hemisphere, this has been achieved through new methods in which radiance data are assimilated more directly into the models. Promising experimental results have also been obtained with 3- and 4-dimensional variational assimilation of TOVS radiances.

- Preparations for Advanced TOVS (ATOVS) data.

Whilst considerable work is still required in this area, inter-agency planning is now under way towards the goal of an international software package for ATOVS data processing.

- Future systems.

Progress was reported towards the implementation of advanced infra-red sounding systems on operational satellites. Recommendations from ITSC-VII in each of these areas are

contained in Appendix A. They were recently presented to the Working Group on Satellites (WGSAT) of the Commission for Basic Systems and endorsed by that group. It was suggested at the WGSAT that the following recommendations be forwarded to the CGMS.

4. Recommendations for the consideration of CGMS

The following issues identified or re-stated at ITSC-VII are brought to the attention of CGMS.

Regarding the use of TOVS data in climate studies:

4.1 TOVS data (from 1978 to the present) represent a unique source of information for climate studies. It is important that the archive of Level IB data at full resolution be maintained and made accessible for use in these studies. Access to long-period, global TOVS data sets remains a significant impediment to climate studies at many institutes. A policy of open access to data at reasonable cost should be encouraged.

4.2 Operational centres are encouraged to include the generation of products for climate studies from TOVS (and other environmental satellite) data in their real-time processing.

Regarding the use of TOVS data in NWP:

4.3 To enable continued operational use of satellite sounder and imager data in local and regional NWP models, real-time direct broadcast data are required. Present plans of NOAA, EUMETSAT and NASA to continue direct broadcast of such data are strongly encouraged.

4.4 Providers of sounding products, including (but not limited to) brightness temperatures and temperature/humidity profiles, should supply users with the expected error characteristics (biases and covariances) of their products.

Regarding preparations for ATOVS data:

4.5 The plans of NESDIS and EUMETSAT to collaborate on the production of an "international ATOVS processing package" is noted and welcomed. Full international availability of such code is highly desirable. Support for the development and maintenance

of such software is recognized as an important issue requiring long-term resourcing.

4.6 Increased activity is required on the science of ATOVS data pre-processing and retrieval in order to produce algorithms of high quality and to exploit these data fully. The revised schedule for the launch of NOAA-K (currently planned for early 1996) represents a significant problem in terms of the readiness of the user community to use these data. A two-phased approach now seems most realistic, whereby ad hoc adaptations to existing TOVS systems will be developed to ensure operational continuity at the launch of NOAA-K and improved ATOVS software packages will be developed later to exploit more fully the capabilities of the new instruments.

Regarding future systems:

4.7 With regard to future operational sounding and imaging instruments, it is desirable that common meteorological requirements and compatible instrument specifications and data formats are developed.

4.8 There is an urgent need for an operational infra-red sounder of high spectral resolution, along with complementary imaging and microwave sounding instruments. Satellite agencies' plans to implement such systems are strongly encouraged.

Regarding education and training:

4.9 With the rapid and continuing growth in the user community for satellite sounding data, there is a growing need for coordinated international training programmes. The offer of ITWG to help with appropriate workshops and/or training sessions is noted.

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Appendix A

**SUMMARY REPORT ON THE SEVENTH INTERNATIONAL
TOVS STUDY CONFERENCE, ITSC-VII**

1.1 INTRODUCTION

The Seventh International TIROS Operational Vertical Sounder (TOVS) Study Conference, ITSC-VII, was held in Igls, Austria, from 10-16 February 1993. 79 participants attended the meeting and provided scientific contributions. 22 countries and 4 international organizations were represented at the meeting: Australia, Austria, Brazil, Canada, People's Republic of China, Republic of China, Czech Republic, Finland, France, Germany, Hungary, Italy, Japan, Republic of Korea, Mongolia, Netherlands, New Zealand, Norway, Russia, Spain, United Kingdom, United States of America, ECMWF, ESA, EUMETSAT and WMO.

Most of the meeting was occupied with scientific presentations on the following broad issues: TOVS data in climate studies, TOVS data in numerical weather prediction, preparations for Advanced TOVS (ATOVS) data, future systems, and other scientific studies and developments. These were given either as oral or poster presentations. The conference papers are published in the "Technical Proceedings of the Seventh International TOVS Study Conference" available through the co-chairs of the International TOVS Working Group (ITWG), Dr J R Eyre (ECMWF) and Dr M J Uddstrom (NIWAR, New Zealand).

During the latter part of the conference, Working Groups were formed to consider four of the main issues identified prior to the conference: TOVS data in climate studies, TOVS data in numerical weather prediction, preparations for Advanced TOVS (ATOVS) data and future systems. The Working Groups reviewed recent progress in these areas, made recommendations on key areas of concern and identified items for action. A session on Status Reports heard reports on relevant meetings and other activities which had taken place since ITSC-VI and reviewed progress on the action items identified by the ITSC-VI Working Groups. Many of these issues formed the basis for further discussion by the Working Groups at ITSC-VII.

During one short session, the conference divided into three Technical Sub-Groups to discuss developments and plans concerning specific software packages in common use among TOVS processing centres.

A "Report on the Seventh International TOVS Study Conference", including abstracts of the presentations and reports from the Working Groups and Technical Sub-Groups, is available from the ITWG co-chairs.

1.2 CONCLUSIONS AND RECOMMENDATIONS

As a result of the activities of the Working Groups and their reports to the final session of the conference, the following conclusions and recommendations were adopted as a summary of the main findings of ITWG at ITSC-VII. More details and specific technical recommendations and actions are given in the full report from the conference.

1.2.1 TOVS data in climate studies

1.2.1.1

ITWG drew attention to the value of TOVS data in the detection of climate signals. The global, continuous and long record (1978-present) of TOVS data, and their broad spectral coverage render them particularly suitable for investigating inter-annual variability of temperature, humidity and cloud cover. It was noted that a number of institutes have now produced results demonstrating the potential of TOVS data in these areas.

1.2.1.2

Noting the predicted sensitivity of polar regions to climate change, ITWG recommended increased attention to the information contained in TOVS/AVHRR data on air-sea-ice energy exchanges. Promising results are already being obtained, but much work is still required to improve methods of data interpretation and processing in polar (and high plateau) areas.

1.2.1.3

ITWG applauded progress in the NASA/NOAA "TOVS Pathfinder" activities and noted that processing of a benchmark data set (March 1987 - February 1989) had begun. It recommended close involvement of ITWG members in evaluation of the benchmark products. ITWG also drew attention to common aspects in the TOVS Pathfinder activities and the re-analysis projects at NMC and ECMWF, and it encouraged increased dialogue between these projects.

1.2.1.4

With regard to the activities of operational centres, ITWG stressed the importance of maintaining the archive of Level IB data at full resolution for use in climate studies. It also encouraged operational centres to include the generation of climate products from environmental satellite data in their real-time processing.

1.2.1.5

Access to long-period, global TOVS data sets remains a significant impediment to climate studies at many institutes. It was recommended that a policy of open access to data at reasonable cost should be encouraged.

1.2.1.6

ITWG encouraged increased and closer links between ITWG and other groups active in climate research.

1.2.2 TOVS data in numerical weather prediction (NWP)

1.2.2.1

At ITSC-VII, it was reported that TOVS data have shown a positive impact on NWP in both hemispheres. This result was demonstrated both for the use of TOVS radiances directly in NWP data assimilation schemes and through improvements in retrieved products generated by NESDIS. ITWG commended NESDIS for their efforts in improving operational TOVS sounding products.

1.2.2.2

Promising, early results from three- and four-dimensional variational assimilation of radiance data were presented.

1.2.2.3

Results from direct assimilation of radiance data also demonstrated the potential of TOVS water vapour channels for improving humidity analyses in NWP models. However significant improvements are required in model parametrization schemes and assimilation methods before this information can be exploited fully.

1.2.2.4

To improve the utilization of radiance data, more accurate fast radiative transfer models are required. At present their deficiencies limit the information which may be extracted from the measured radiances. It was recommended that this problem be addressed through the generation of high quality collocation data bases of satellite and in situ data, and through the acquisition of high spectral resolution radiances from ground- and aircraft-based platforms. The planned use of the latter by ITRA, in order to validate both line-by-line and fast radiance/transmittance codes was strongly supported.

1.2.2.5

It was recommended that providers of sounding products including (but not limited to) brightness temperatures, and temperature/thickness and water vapour profiles provide users with the expected error characteristics (biases and covariances) of their products.

1.2.2.6

To enable continued operational use of satellite sounder and imager data in local and regional NWP models, real-time direct broadcast data are required. Present plans of NOAA, EUMETSAT and NASA to continue direct broadcast of such data were warmly welcomed.

1.2.2.7

With the anticipated wider use of global satellite radiances at NWP centres, the present limited bandwidth of much of the GTS will prevent their full utilization. It was recommended that WMO should plan for increased bandwidth on the GTS to accommodate these data.

1.2.3 Preparations for ATOVS data

1.2.3.1

It was noted that NESDIS has offered to make available to EUMETSAT their "RTOVS" code, as a basis for development of a processing package for ATOVS data. EUMETSAT plans to develop the code, in collaboration with NESDIS and other centres, in order to provide an international ATOVS processing package. ITWG welcomed these developments and expressed its thanks to NESDIS and EUMETSAT for their assistance in this important area.

1.2.3.2

ITWG stressed the desirability of full international distribution (i.e. beyond EUMETSAT member states and NESDIS) for ATOVS processing code and recommended that the matter be brought to the attention of the Co-ordination Group for Meteorological Satellites (CGMS).

1.2.3.3

ITWG noted that considerable work is still required on the science of ATOVS data pre-processing and retrieval in order to produce algorithms of high quality in time for use at the launch of NOAA-K. It encouraged its members to devote increased activity to this area.

1.2.3.4

In addition to the "RTOVS" code, which applies pre-processing and retrieval algorithms to Level IB data, it was noted that there is also a requirement for standard "Ingest" code to convert locally-received raw ATOVS data to Level IB data. Continuing discussion with NESDIS and EUMETSAT was recommended on these issues to ensure the production and distribution of standard ingest code prior to the launch of NOAA-K.

1.2.3.5

The availability of detailed specifications of the characteristics of ATOVS instruments will be crucial to successful exploitation of their data. It was recommended that, when available, NESDIS draft documentation (i.e. the equivalent of NOAA Tech Rep NESS 107 for TOVS) should be made available to ITWG members for comment. It was also suggested that electronic access (e.g. via Internet) to instrument data would be a very effective method of dissemination to users.

1.2.4 Future systems

1.2.4.1

With regard to future operational sounding and imaging instruments, meteorological requirements and compatible instrument specifications and data formats. ITWG would welcome initiatives by CGMS in this area.

1.2.4.2

ITWG re-iterated the urgent need for an operational infra-red sounder of high spectral resolution, along with complementary imaging and microwave sounding instruments.

1.2.4.3

Full exploitation of advanced sounder data will require improvements in atmospheric transmittance models. In this area, ITWG strongly endorsed the development and validation activities of ITRA.

1.2.4.4

To enable wider scientific input in the specification of and preparation for advanced sounding instruments, it was recommended that present and planned synthetic high spectral resolution data sets and associated software be made available to the research community.

1.2.4.5

NASA's plan to install a direct broadcast facility on some of the EOS platforms was warmly welcomed by ITWG.

1.2.4.6

Given the possibility of reducing significantly the HIRS/3 instantaneous field of view (ifov) while retaining the radiometric sensitivity of HIRS/2, ITWG recommended that the specification of the HIRS/3 ifov be changed to reflect this possibility at the earliest possible date.

1.3 FUTURE PLANS

ITSC-VII considered a draft report entitled "ITWG: a Strategy for the 1990s" prepared by the co-chairs. It endorsed the report with some modification. This report reviews the activities and achievements of the first decade of ITWG. It sets out revised aims for the group and proposes specific objectives for the next few years. With regard to the formal status of ITWG and its relationships with and other bodies, ITSC-VII endorsed the following statement, to form part of the "Strategy" document:

- ITWG should retain its present status in relation to the Radiation Commission of IAMAP (i.e. as an ad hoc working group),

- ITWG should seek to establish interactions with CGMS, to provide a more direct channel to/from the operational satellite agencies,
- ITWG should continue to develop appropriate links with WMO.

The next meeting of ITWG is planned for early 1995 at a venue in New Zealand. ITSC-VIII will attempt to carry forward progress identified at ITSC-VII in the areas of NWP and climate studies, and will address some of the new concerns (identified in the Working Groups' reports) on selected aspects of the science underlying TOVS data processing. It will continue to review international efforts toward future satellite sounding systems. In particular, the timing of ITSC-VIII is likely to make it a key meeting in the international TOVS community's plans to collaborate on developing processing software for data from the ATOVS instruments on NOAA-K.

STATUS OF WMO SATELLITE DATA REQUIREMENTS

(Submitted by the WMO Secretariat)

Summary and purpose of document

This working paper contains the latest status in the development of WMO Satellite Data Requirements

ACTION PROPOSED

CGMS is invited to:

1. Note the latest status in the development of WMO Satellite Data Requirements and comment as appropriate.

- Appendix:
- A. EXCERPT FROM CBS/WG/SAT-I/Doc.6, SATELLITE DATA, PRODUCTS AND SERVICE REQUIREMENTS OBSERVATIONAL GOALS FOR GLOBAL NUMERICAL WEATHER PREDICTION
 - B. EXCERPT FROM CBS/WG/SAT-I/Doc.16, REPORT OF SUB-GROUP ON SATELLITE DATA, PRODUCTS AND SERVICE REQUIREMENTS

NOTE: The Appendix B is not included in the publication of the report of CGMS-XXII.

DISCUSSION

1. The CBS Working Group on Satellites met 7-11 March 1994 and discussed the WMO Satellite Data Requirements under its agenda item 3.1. There several relevant pre-session documents for the working group including discussions on observational goals for global NWP and activities of the sub-group on satellite data, product and service requirements.
2. Although not recorded in this working paper, the CBS Working Group on Satellites also reviewed the latest version of the CEOS Affiliates' Dossier that can be found in Volume C of the CEOS Dossier dated September 1993.
3. CBS/WG/SAT-I/Doc.6 contained guidance on the range of observations useful in global numerical weather prediction (NWP). An excerpt from document 6 can be found in Appendix A.
4. CBS/WG/SAT-I/Doc. 16 contained the report from the Sub-group Chairman on Satellite Data, Products and Service Requirements. An excerpt from document 16 can be found in Appendix B. Several sections in Appendix B contain insights into the manner in which the CBS Working Group is considering interacting with the satellite operators. In particular, paragraphs 2.1 notes that WMO statements intended to persuade those who design, launch and operate satellites, to meet specific user needs, should be easy to read and assimilate for that community. Paragraph 2.3 notes that some such guidance will be unwelcome to instrument designers/providers. It must be pressed forcefully therefore but exposed to subsequent debate. The documentation being described cannot hope to be sufficient to inform that debate, but should initiate it - between the potential users and suppliers. It is for this reason (amongst others) that the heritage of user requirements must be clear and well documented.
5. The CBS Working Group on Satellites discussed the objectives of the Sub-group on Satellite Data, Products and Service Requirements those being:
 - to build upon the work of the EC Panel of Experts on Satellites (ECSAT) in collecting, collating, keeping under review, interpreting and promoting to potential providers and their agents, statements of the satellite data, products and services required by WMO Members.
 - to reassure the user community that their needs are being properly interpreted and promoted;
 - to assist developing countries to identify opportunities to make use of satellite data, products and services.
6. The Chairman of the Sub-group intended that the Sub-group accomplish these objectives:
 - through publications and statements written for potential data, product and service providers;
 - in the context of WMO's general requirements for space and ground based observations, by providing the CBS Working Group on Observations with draft material suitable for its use in maintaining and updating the Guide and Manual on the GOS;
 - by some form of data base of requirements which retains their heritage, so that the ownership and responsibility for continued verification are clear. It is expected that the WMO Secretariat will maintain this and facilitate its regular refreshment by the Technical Commissions and others as appropriate. Such a data base will be the basis of any future short-form or digest of requirements.

7. The CBS Working Group on Satellites agreed with the Sub-group Chairman and suggested that the sub-group clearly identify its actions with regard to reassuring the user communities of its actions. The sub-group should investigate the standardization of procedures towards achieving quality of observations. A most important facet of the sub-group's responsibility will be its ability to interpret and translate input from the user communities into information useful by the satellite operators as well as insuring that appropriate co-ordination occurs amongst the various WMO groups involved with developing data requirements. A primary focus should be towards convergence between the requirements of the users and realistic expectations.

8. Following discussions within the sub-group the CBS Working Group on Satellites endorsed the following proposals:

- the sub-group will prepare a critical review of WMO requirements for satellite data, products and allied services, and of the capabilities to meet them as set out in the Appendix B. This is referred to as Task A in the Work Plan.
- to conduct the critical review by pursuing a "pathfinder" approach, i.e. by revising requirements for data and adding requirements for products and allied services for a few, representative applications before applying the approach to capture all relevant WMO requirements.
- agreed accordingly to characterise the sources of requirements for operational meteorology and climate research.

9. The CBS Working Group on Satellites discussed a document prepared by the Rapporteur on Satellite Soundings entitled "Observational goals for global NWP" that proposed guidance on the range of observations which, if available, would be useful in global NWP, either for assimilation into models or for model validation. The document addressed "goals" rather than "requirements". It did not address issues of feasibility, nor was it limited to observations from satellites. It attempted to look 7-10 years ahead, and thus to provide guidance relevant to the planning of new or improved satellite systems. Goals were specified for a range of atmospheric and surface variables in terms of horizontal and vertical resolution, accuracy, frequency and timeliness. However it was stressed that these geophysical variables were in general not observed directly from satellites, and that new methods of data assimilation are increasingly able to make direct use of quantities as observed (e.g. radiances).

10. The CBS Working Group on Satellites agreed that the document was most valuable that required official WMO status. In this regard, the CBS Working Group on Satellites was pleased to note that the document would be presented to the forthcoming meeting of the joint Task Team of the CBS Working Groups on Observations and Data Processing addressing data requirements. The CBS Working Group on Satellites also strongly suggested that co-ordination of such requirements was required with the full Working Group on Data Processing. One additional characteristic was suggested to cover flexibility which was meant to imply the limits under which data would become useless or even harmful. The CBS Working Group on Satellites also suggested that the "Goals" should include a description of incremental improvements expected given that a stated improvement in data observation quality was achieved.

APPENDIX A

**EXCERPT FROM CBS/WG/SAT-I/Doc.6
SATELLITE DATA, PRODUCTS AND SERVICE REQUIREMENTS
OBSERVATIONAL GOALS FOR GLOBAL NUMERICAL WEATHER PREDICTION**

1. PURPOSE

1.1 The purpose of this document is to provide draft guidance on the range of observations which would be useful in global numerical weather prediction (NWP), if they were available.

2. GOALS AND REQUIREMENTS.

2.1 The information presented here should be interpreted as "goals", rather than as "requirements". The term "goals" is used to mean that data of a given specification would be useful if available, and that data of higher specification (in terms of resolution, accuracy, etc.) would not be significantly more useful for this application. The term "requirements" is thought to be inappropriate since it implies that the application (in this case, global NWP) cannot be carried out satisfactorily without such data, and also that data which do not meet these specifications will not be useful. In both respects this is clearly not the case; NWP models produce useful products even with the observational data set currently available, and new data which met a specification lower than that stated would often benefit NWP since they would represent a significant improvement to the operational observing system.

3. STRATEGY AND SOURCES OF INFORMATION

3.1 This document has been prepared following a review of the information contained in reports of the WMO EC Panel of Experts on Satellites (Reports on 9th and 10th sessions, and Final Report), and various documents prepared by satellite agencies and other groups. However, rather than propose detailed modifications to the specifications given in these documents, it was decided to re-visit the problem from the user's perspective and not to be constrained by current practice or by present or planned technology or by perceived limits to observational technologies. The document seeks to answer the question: what types of observations would be useful within global NWP if they could be made? It also seeks to present an internally self-consistent set of goals for this application.

3.2 The document has drawn on input from several colleagues at ECMWF who are concerned with research and development in data assimilation and model validation. It is anticipated that goals identified by other global NWP centres would be similar, but this has not been established; comments from such centres on the goals proposed here would be most welcome.

4. SCOPE

4.1 Observations are required to provide an analysis of atmospheric and surface fields, to be used as the initial conditions for the numerical forecast. Usually information is extracted from observations within a data assimilation system, which blends new observations with an existing estimate of the atmospheric state carried by the forecast model itself. In addition to their use in analysis/assimilation, observations are required to provide information for validation of improvements made to the models themselves. These two aspects have been considered here.

4.2 Developments in parametrizations used in NWP models make use of advances in the understanding of processes not explicitly represented by the models. The observational goals for such process studies have not been addressed here, but they are clearly important to long term developments in NWP.

5. OBSERVATIONAL FEASIBILITY

5.1 As indicated above, the problem of the feasibility of observing all the variables listed is not addressed. Indeed, in the case of some atmospheric/surface variables, it is likely that our best knowledge of them will come from the output NWP data assimilation schemes, making full and consistent use of observations related to other, more accessible variables.

6. THE ROLE OF SATELLITES

6.1 Most of the goals stated here could only be met, if at all, by satellite-borne observing systems. However, it is not essential that all information needed to meet or approach these goals should come from satellites. *No attempt has been made here to identify the most appropriate observing systems to meet the stated goals.*

7. LEAD-TIMES

7.1 The main purpose in defining observational goals is to inform discussion on the development of new or improved observing systems. In the case of satellite observations, new systems have lead-times of 7 years or more. Therefore the observational goals stated here are intended to be consistent with the probable state of development of global NWP systems on this timescale, i.e. in 7-10 years time.

8. SPECIFICATION OF GOALS

The attached three tables give the goals for observational information on a list of geophysical variables. The following notes provide some explanation of how the lists were prepared and some provisos on their use.

8.1 VARIABLES

8.1.1 Following past convention, the observational goals are stated in terms of geophysical variables. This is thought to be useful since, from a user's perspective (the user here being the global NWP centre), these are the variables on which information is required. However it is important to note that these variables are not in general observed directly. Satellite systems observe none of them directly (with the exception of top-of-the-atmosphere (TOA) radiation), and even conventional systems infer some of them by indirect means. Also it is no longer true that the users need their data exclusively in the form of geophysical parameters; recent developments in data assimilation, for example in NWP, have demonstrated the potential and the benefits of using data at the engineering level (e.g. radiances, brightness temperatures, backscatter coefficients). These trends should be taken into account when developing the data distribution systems through which the observations reach the users.

8.1.2 For short- and medium-range NWP, it is adequate to consider only the surface of the ocean. If the range were extended to include seasonal forecasting, then observations of the ocean down to the thermocline would be also be needed. Specifications for this application have not been considered further in this paper.

8.2 HORIZONTAL RESOLUTION

8.2.1 In general (and with some over-simplification), data are useful for assimilation and validation on spatial scales which the models are attempting to represent. On the timescales in question, for global NWP, this is expected to be scales corresponding to a grid-length of ~50 km. Therefore 50 km is given as the goal for most of the variables in the tables. However, for land processes, models are expected to develop to make explicit representation of sub-gridscale inhomogeneities, and so a higher resolution (15 km) has been specified for relevant variables.

8.3 VERTICAL RESOLUTION

8.3.1 The same rationale is applied here: NWP models are expected to have a resolution in the

atmosphere of ~ 1 km throughout the troposphere and lower stratosphere, with slightly enhanced resolution around the tropopause and considerably higher resolution in the planetary boundary layer. In the mid and upper stratosphere a resolution of 2-3 km is likely to be sufficient. The goals for observations should be comparable.

8.3.2 At the surface the vertical aspects have been characterized by three values where appropriate: a near surface air value, a skin value and a bulk value for the "surface layer". For the sea, this should be adequate for short- and medium-range NWP. For land and ice, it is desirable to have some information on the profile to a depth ~ 1 m, and this has been indicated where appropriate.

8.4 ACCURACY

8.4.1 The values given are intended to represent the standard deviations of the observation errors on the assumption that the errors have a distribution close to normal and that the biases are small relative to the standard deviations. It is important to note that biases should not only be small globally but also locally (which is not the case for some current observations, e.g. temperature profiles retrieved by conventional techniques from satellite radiances).

8.4.2 The assessment of accuracy should include not only the true instrumental error and errors introduced in the pre-processing of the data, but also so-called "errors of representativeness", i.e. the characteristics of some observing systems, particularly in situ systems, to sample spatial and temporal scales which are not represented by the models. For NWP applications, such effects appear as though they were observation errors. This is an added complication when specifying observational goals, as it makes the "errors" application-dependent. Nevertheless, it is an important consideration.

8.5 FREQUENCY

8.5.1 Just as with spatial resolution, data will be useful for assimilation and validation on temporal scales which the models are attempting to represent. In the past this has not been the case; so-called "four-dimensional" assimilation systems would more appropriately be described as "intermittent three-dimensional" systems, and they have not been able to make proper use of observations more frequent than the period of the data assimilation cycle (typically 6 hours). However, continued progress towards truly four-dimensional data assimilation is making it possible to extract useful information from observations at higher temporal frequency. With such systems, higher temporal resolution can compensate for poor horizontal resolution when the atmosphere is moving. For these reasons, a goal of 1 hour has been specified for all variables which change rapidly in time.

8.6 TIMELINESS

8.6.1 In NWP, the value of data degrades with time, and it does so particularly rapidly for variables which change quickly. This has been taken into account in the specifications for the timeliness of observations. For observations which are expected to be used for validation, and not for analysis/assimilation in near real-time, the timeliness is less critical, but the availability of observations or derived products with a delay not exceeding 1-2 month is usually helpful.

Table 1**Three-dimensional fields**

	Horizontal res. (km)	Vertical res. (km)	Accuracy	Frequency	Timeliness
Wind (horizontal)	50	1 ¹	1 m/s, 5% ^{2,3}	1 h	2 h
Vertical velocity	50	1	0.01 m/s	1 h	2 h
Temperature	50	1 ¹	1 K	1 h	2 h
Relative humidity	50	1 ¹	5%	1 h	2 h
Cloud water	50	1 ¹	20%	1 h	2 h
Cloud ice	50	1 ¹	20%	1 h	2 h
Ozone	50	1	20%	1 h	2 h
Rain (CW > 100 μm)	50	1	20%	1 h	2 h

Notes:

- ¹ Higher resolution in planetary boundary layer
- ² Where 2 accuracies are given, the one leading to the larger value should be taken
- ³ Vector error

Table 2

Surface fields

	Horizontal res. (km)	Accuracy	Frequency	Timeliness
Pressure	50	0.5 hPa	1 h	2 h
Wind (10 m)	50	1 m/s, 5% ^{*2,*3}	1 h	2 h
Temperature (2m)	50	1 K	1 h	2 h
Relative humidity	50	5%	1 h	2 h
Accumulated precipitation	50	0.1 mm, 5% ^{*2}	1 h	2 h
Temperature, sea skin	50	0.5 K	1 h	2 h
Temperature, sea, bulk	50	0.5 K	1 day	1 day
Temperature, land, skin	15	1 K	1 h	2 h
Temperature, land soil	15	1 K	1 h ^{*4}	1 h
Sea-ice cover	15	10%	1 day	1 day
Sea-ice depth	15	0.2 m	1 week	1 week
Snow cover	15	10%	1 day	1 day
Snow equivalent-water depth	15	5 mm, 10% ^{*2}	1 day	1 day
Soil moisture, 0-10 cm	15	0.02 m ³ /m ³	1 day	1 day
Soil moisture, 10-100 cm	15	0.02 m ³ /m ³	1 week	1 week
Vegetation index (NDVI) ^{*7}	15	0.01	1 week	1 week
Leaf-area index	15	0.5	1 week	1 week
Runoff	50	0.5 mm/day	1 week	1 month ^{*5}
Evaporation	15	0.5 mm/day	1 h	2 h
Sensible heat flux	15	5 W/m ²	1 h	2 h
Albedo, visible	15	1%	1 day	1 day
Albedo, near infra-red	15	1%	1 day	1 day
Longwave emissivity	15	1%	1 day	1 day
Net shortwave radiation	15	5 W/m ²	1 h	1 month ^{*5}
Net longwave radiation	15	5 W/m ²	1 h	1 month ^{*5}
Ocean wave height	50	0.5 m, 10% ^{*2}	1 h	2 h
Ocean wave period	50	0.5 s	1 h	2 h
Ocean wave direction	50	10 deg.	1 h	2 h
Ocean wave energy spectra	50	^{*5}	1 h	2 h

Notes:

- *2 Where 2 accuracies are given, the one leading to the larger value should be taken.
- *3 Vector error.
- *4 Information is also required as a function of depth. In the upper layers (< 10 cm depth) diurnal variations are important, whereas for deeper layers (~ 1m) weekly information would be adequate.
- *5 Accuracy required is 20% in spectral wave energy with a resolution of 10% in frequency and 15 deg. in direction.
- *6 Required principally for model validation; not time critical.
- *7 NDVI is anomalous in this list; it is associated with a particular technology rather than being a user requirement. It has nevertheless been retained as a useful index of the seasonal changes in vegetation cover and properties.

Table 3

Other two-dimensional fields

	Horizontal res. (km)	Accuracy	Frequency	Timeliness
Cloud top height	50	0.5 km ^{*8}	1 h	2 h
Cloud top temperature	50	1 K	1 h	2 h
Cloud base height	50	0.5 km ^{*8}	1 h	2 h
Cloud fractional cover	50	10%	1 h	2 h
TOA net shortwave radiation	50	5 W/m ²	1 h	1 month ^{*6}
TOA net longwave radiation	50	5 W/m ²	1 h	1 month ^{*6}
Multi-purpose IR/VIS imagery ^{*9}	5	-	30 min	2 h

Notes:

- *6 Required principally for model validation; not time critical.
- *8 Higher in planetary boundary layer; 0.05-0.1 km for Sc/St.
- *9 Required to assist real-time observation monitoring and analysis/forecast validation.

WMO STRATEGY
FOR
EDUCATION AND TRAINING IN SATELLITE MATTERS

(Submitted by the WMO Secretariat)

Summary and purpose of document

This working paper contains the latest status in the development of the WMO Strategy for Education and Training in Satellite Matters

ACTION PROPOSED

CGMS is invited to:

1. Note the latest status on the WMO Strategy for Education and Training in Satellite Matters and comment as appropriate.

- Appendix:
- A. EXCERPT FROM CBS/WG/SAT-I/Doc. 4, WMO STRATEGY FOR EDUCATION AND TRAINING
 - B. EXCERPT FROM CBS/WG/SAT-I/Doc.17, EDUCATION AND TRAINING
 - C. Preliminary Information Analysis of the Capabilities of WMO RMTCs

NOTE: Appendix A and B are not included in the publication of the report of CGMS-XXII.

DISCUSSION

1. The CBS Working Group on Satellites met 7-11 March 1994 and discussed the new training strategy involving sponsorship of specialized RMTCs by satellite operators under its agenda item 4.1. The Working Group's relevant pre-session documents were CBS/WG/SAT-I/Doc.4 and CBS/WG/SAT-I/Doc.17.
2. Appendix A is an excerpt from CBS/WG/SAT-I/Doc.4. Document 4 reviewed progress with three major tasks associated with the development and implementation of the strategy for education and training in satellite applications approved by EC-XLV. Several recommendations were made for CBSWGSAT-I consideration including the consolidation and use of the list of experts in satellite applications (see Annex I of Appendix A), the development of specifications for the proposed new Specialized Satellite Training Centres at RMTCs (see Annex II of Appendix A) and a mechanism and timetable for the difficult task of preparing a fully costed plan to implement the education and training strategy for consideration by Congress in 1995.
3. Appendix B is an excerpt from CBS/WG/SAT-I/Doc.17. Document 17 contained information on activities within the WMO Secretariat in relation to satellite education and training matters. Its purpose was to enable the CBS Working Group on Satellites to review these activities and make the necessary recommendations for the development and improvement in satellite data applications of education and training. It identified training events held in 1993 and planned for the biennium 1994/1995. It also recorded recommendations emanating from the report of the fifteenth session of the EC Panel of Experts on Education and Training.
4. The CBS Working Group on Satellites was briefed on the status of the new Strategy for Education and Training in the use of satellite data and considered three major issues:
 - (a) further refinement of the strategy approved by EC-XLV in the light of consultation with satellite operators, other WMO Programmes and other relevant organizations involved in satellite education and training matters;
 - (b) assistance to the EC Panel on Education and Training in identifying RMTC candidates for Specialized Satellite Training Centres at RMTCs; and
 - (c) preparation of a costed plan to implement the Strategy, for consideration by Congress in 1995.
5. The CBS Working Group on Satellites noted that the Strategy for Education and Training had been presented to CGMS-XXI. The three objectives of the Strategy were explained to CGMS-XXI including building on the existing infrastructure, focusing on the developing countries and anticipating future trends in satellite data applications. **The CBS Working Group on Satellites was pleased to learn of CGMS's great interest in the proposal to establish six specialized satellite centres at RMTCs. With regard to the proposal that each satellite operator adopt at least one of the six centres, CGMS had agreed in principle with the Strategy and also to a willingness to further discuss the proposal with WMO. CGMS had indicated that WMO should further identify specific needs to aid potential CGMS supporters in evaluating resource requirements for such sponsorship, together with proposed implementation dates.**
6. The CBS Working Group on Satellites also noted that the EC Panel on Education and Training had agreed that all RMTCs should be surveyed on their capabilities and availabilities or wishes to participate under the strategy as specialized centres for satellite training. The EC Panel further agreed that the findings of the survey should be relayed to the CBS Working Group on Satellites with a view to involvement of the satellite operators in arrangements to develop the satellite training capabilities at suitable centres. The EC Panel expressed the hope that this would lead to arrangements between the satellite operators and some RMTCs for the development of satellite training programmes.

7. The CBS Working Group on Satellites was informed by the Education and Training Programme Secretariat of responses from some RMTCs as to their interest and capability to serve as specialized satellite training centres.

8. The CBS Working Group on Satellites reviewed and updated the list of experts in satellite applications who could assist with implementing the training strategy via participation in special seminars, "train the trainer" activities, and development of computer assisted learning modules on satellite applications. The group decided to incorporate two additional pieces of information into the list: the person's affiliation, and identification as a training expert or an expert in a particular field. The updated list can be found in Appendix A, Annex I. **WMO would be pleased to add the names of any trainers or experts that CGMS wishes add to the Annex and to provide the Tables for use by CGMS.**

9. The CBS Working Group on Satellites also agreed on a set of specifications (see Appendix A, Annex II) for Specialized Satellite Training Centres at RMTCs where local talent could best be fostered. It noted that the set of specifications would be of value to the EC Panel on Education and Training to help identify and establish such centres at selected RMTCs. These specifications need further refinement when a more detailed specification of standard WMO satellite reception and processing facilities becomes available.

10. The CBS Working Group on Satellites conducted a preliminary analysis of the relative suitability of the various RMTCs as candidates for designation as Specialized Satellite Training Centres. The preliminary analysis assessed each candidate RMTC against each of the specifications given in Appendix A, Annex II in light of information provided by the Education and Training Programme Secretariat and other information previously compiled by the EC Panel of Experts on Satellites. **This resulted in a preliminary information analysis grid, shown in Appendix C, which the CBS Working Group on Satellites recommended be provided to CGMS, CEOS and the EC Panel on Education and Training, to assist them in their deliberations on this matter.**

11. The CBS Working Group on Satellites's preliminary conclusions from examining the information in Appendix C were:

(a) The RMTC's best suited at present for enhancement to Specialized Satellite Training Centres were (two RMTCs were indicated in the Regional Associations where there were four or more candidate RMTCs):

- In WMO RA I:
 - Kenya (Nairobi);
 - Niger (Niamey);
- In WMO RA II:
 - China (Nanjing);
 - India (New Delhi);
- In WMO RA III:
 - Argentina (Buenos Aires);
- In WMO RA IV:
 - Costa Rica (San Jose);
- In WMO RA V:
 - Philippines (Manila);

- In WMO RA VI:
 - no RMTCs located in a developing country

12. In addressing a mechanism to identify costing information more clearly, the CBS Working Group on Satellites agreed that a trial project should be implemented as soon as possible for one or two Specialized Satellite Training Centres. **This would necessitate the involvement of the satellite operators and any other sponsors.** The CBS Working Group on Satellites suggested that the Executive Council be informed of this approach and that the Secretary-General write to the satellite operators seeking their involvement. Once the trial projects had identified the resource requirements, then WMO would be in a position to plan properly for the centres through the normal programme and budgeting process.

13. In reaching the above conclusions the CBS Working Group on Satellites made the following observations:

(a) There was an ongoing need to obtain more detailed information on the current and potential capabilities of all RMTCs in the light of the newly agreed specifications for Specialized Satellite Training Centres and to update the preliminary information analysis grid (Appendix C). It was deemed essential that site visits be undertaken as soon as possible to evaluate more precisely the facilities and needs at the various RMTCs for possible establishment as Specialized Satellite Training Centres after the completion of the trial project;

(b) There were special problems to be addressed in RA II concerning the effectiveness of satellite applications training for Arabic speaking people until a Specialized Applications Training Centre can be established in an Arabic country. The RMTC in Egypt (RA I) would be a worthwhile consideration in this context.

(c) In RA III there was an anomaly in Brazil in that the RMTC in Belem seemed to be poorly placed for enhancement into a Specialized Satellite Training RMTC but there was an excellent base and an emerging opportunity for enhancement at INPE (which was organizationally outside the WMO RMTC structure). There was already a national space organization in Brasil with a number of experts and facilities available at various institutions (e.g. INPE, FUNCEME).

(d) A needs analysis should be undertaken as soon as possible to determine the relative needs (and hence the potential costs) of existing RMTCs for enhancement into Specialized Satellite Training Centres.

(e) A final decision on selection of RMTCs for enhancement into Specialized Satellite Training Centres depends on diverse considerations. For example, some RMTCs (eg: Manila) have recently benefited for major foreign aid programs in remote sensing and hence could be established as Specialized Centres with little or no further capital outlay. Their main initial support requirement would be on further enhancement of the ongoing "train the trainers" activities. On the other hand, there were several RMTCs (e.g. Egypt, Barbados, Nigeria) who were very willing to participate in upgraded local satellite applications training but would require significant initial resources to enhance their capabilities.

14. The CBS Working Group on Satellites was concerned that implementation of the overall education and strategy proceeded as rapidly as possibly within ongoing programmes and budgets while the matter of Specialized Satellite Training Centres was being addressed. To this end the CBS Working Group on Satellites recommended that:

(a) A specific coordinator/contact person should be nominated immediately in each RMTC and in the ETPR Secretariat (as an overall coordinator) as a basic management structure for information flow and local action on implementing the satellite education and training strategy. These people should participate in the training seminar on the management of training centres which is scheduled for 1994-95 under the Education and Training Programme.

(b) A mechanism should be established for linking RMTCs to ongoing education and training programmes outside the WMO structure (e.g.: the training programmes of the IOC and the

UNESCO/BILKO Programme). There is a clear willingness by such programmes to cooperate and such cooperation would certainly improve the effectiveness of the strategy and would accelerate its implementation.

15. WMO, therefore, seeks the response from CGMS as to further implementing the Strategy for Education and Training in Satellite Matters.

**Preliminary Information Analysis of the Capabilities of WMO Regional Meteorological Training Centres (RMTCs)
to meet the Specifications of Specialized Satellite Training Centres. (March 1994)**

Note: Annex is incomplete, more information is needed and will be added by the Rapporteurs on Education and Training, (√ implies yes, [blank] implies no and ? implies unable to determine from available information)

RMTC	Pre Requisites			Organizational Support					Special Facilities								Other comments			
	Services and Accessibility	Satellite applications in curricula	Located in a developing country	Link to NMS	Link to University	National Space Program	Link to Satellite Operator training	Non-WMO sponsorship	Satellite data access				Computing Facilities	CAL Programme	Teaching Laboratory	Suitable teaching personnel	Communications services and	WMO Language	Interested in project	Miscellaneous
									Geo		Polar									
									LR	HR	LR	HR								
RA-I																				
Algeria		√	√		√			√					√	√	?	F	√			
Angola			√																	
Egypt			√	√	√		√	√						√				√		
Kenya	√	√	√	√	√		√		√		√		√	√	√	E	√			
Madagascar			√													F				
Niger	√	√	√	√	?		?	?	√		√	√	√	√	√	F	√			
Nigeria	√	√	√					√		√			√	√	?					

A.119

RMTC	Pre-Requisites			Organizational Support				Special Facilities						Other comments				
	Services and Accessibility	Satellite applications in curricula	Located in a developing country	Link to NMS	Link to University	National Space Program	Link to Satellite Operator training	Non-WMO sponsorship	Satellite data access		Computing Facilities	CAL Programme	Teaching Laboratory	Suitable teaching personnel	Communications services and	WMO Language	Interested in project	Miscellaneous
									Geo	Polar								
	LR	HR	LR	HR	LR	HR												
RA-II																		
India	✓	✓	✓	✓	✓	✓			✓		✓	✓	✓	✓		E	✓	
Iraq			✓															
Iran			✓							✓								
China	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓		E, C	✓	
RA-III																		
Brazil			✓		✓	✓	?		✓	✓	✓	✓	✓	✓			✓	
Argentina	✓	✓	✓	?	✓				✓	✓	✓	✓	✓	✓		S		
Venezuela	✓	✓	✓	?	✓				✓		?	✓	✓	✓		S	✓	
RA-IV																		
Costa Rica	✓	✓	✓	✓	✓		?		✓		?	✓	✓	✓		S	✓	
Barbados	✓	✓	✓		✓							✓	✓	✓		E	✓	
RA-V																		
Philippines	✓	✓	✓	✓	✓			✓	✓	✓	✓	✓	✓	✓		E	✓	

Other comments	Miscellaneous					
	Interested in project					
Special Facilities	WMO Language				E, F, S	
	Communications services and				✓	
	Suitable teaching personnel				✓	
	Teaching Laboratory				✓	
	CAL Programme				✓	
	Computing Facilities				✓	
	Satellite data access	Polar	HR		✓	
			LR		✓	
		Geo	HR		✓	
			LR		✓	
Organizational Support	Non-WMO sponsorship					
	Link to Satellite Operator training				✓	
	National Space Program				✓	
	Link to University				✓	
	Link to NMS				✓	
Pre-Requisites	Located in a developing country					
	Satellite applications in curricula				✓	
	Services and Accessibility				✓	
RMTC						
				<u>RA-VI</u>		
					Italy	

CGMS XXII FINAL REPORT

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 Organization (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 harmonized 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,

RECOGNIZING the importance of operational meteorological satellites for monitoring and detection of climate change,

AND RECOGNIZING 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 Appendix A.
- 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 of CGMS 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 CIS	-	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)

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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
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)
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
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)
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

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
TOMS	Total Ozone Mapping Spectrometer
TOVS	TIROS Operational Vertical Sounder
UHF	Ultra High Frequency
UK	United Kingdom
UN	United Nations
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
WV	Water Vapour
WWW	World Weather Watch
X-ADC	Extended Atlantic Data Coverage