REPORT OF THE EIGHTEENTH MEETING OF CO-ORDINATION OF GEOSTATIONARY METEOROLOGICAL SATELLITES

CGMS XVIII

WORLD METEOROLOGICAL ORGANIZATION,

GENEVA, SWITZERLAND,

13-17 NOVEMBER 1989

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CGMS-XVIII

Held at the Headquarters of the World Meteorological Organization
Geneva, Switzerland, from 13 to 17 November 1989

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A. PRELIMINARIES

A.1 Introduction

CGMS-XVIII was convened at 10 am on 13 November by Mr. S. Mildner, Director, Basic Systems, World Weather Watch Department of the World Meteorological Organization, on behalf of the Secretary General, Prof. G.O.P. Obasi. Mr. Mildner conveyed to the session the welcome of the Secretary-General who was not able to attend the session personally because of prior travel commitments.

Mr. Mildner took the opportunity to congratulate the CGMS for its remarkable record of achievements toward the better co-ordination of geostationary satellites. He noted that the satellite programme was central to the support for many facets of WMO programmes, particularly the WWW, and that the CGMS had become the model for international co-operation in the satellite arena.

He recalled to the session the challenges in the past which had been successfully met by the CGMS participants, such as the agreement to ensure coverage over the Atlantic ocean in the face of the problems with first a Meteosat and later a GOES satellite. He noted that the challenges for the future, including the three-axis stabilised geostationary satellite, digital data distribution, continuity of both the geostationary and polar satellite programmes and the addition of new satellite operators, figured prominently on the agenda of the session. He further noted that the recent explosion in technology, in personal computers as one example, was changing the fundamental way that meteorologists were doing their work. He therefore urged the session to not only consider known challenges, but to try to anticipate those fundamental challenges which were being generated by the technological revolution.

In closing Mr. Mildner again wished the participants a successful meeting on behalf of the Secretary-General and noted that the WMO was pleased to play an active and full part in the CGMS. One of the goals of the WMO in its membership, was to improve the interaction between the Members and the CGMS so that the investment being made by the satellite operators could better serve the world.

The reader should note that a full list of acronyms and abbreviations can be found in Annex I.

A.2 Election of Chairman

Mr D.E. Hinsman, Senior Scientific Officer, Satellite Activities, nominated by Mr. J Morgan, was unanimously elected chairman.

The Chairman welcomed the Members of CGMS and discussed the extremely interesting meeting of the EC Panel of Experts on Satellites which was held in the WMO Secretariat the previous week. He noted that the WMO was very fortunate in being able to arrange both of these meetings to follow one another. This presented the opportunity to have a concentrated period of two weeks to consider both the organizational and programme aspects of meteorological satellites, as well as the practical matters concerning their operation. He noted that it was clear that the coming decade would be an exciting one for the satellite programme. The substantial changes in progress and those planned presented the meteorological community with great opportunities and challenges.

He noted that the opportunities and challenges to be faced might be grouped into three broad categories: (1) consideration of and agreement on the proper and efficient operation of the existing system of satellites; (2) the establishment of a foundation for making an orderly change to incorporate new satellite capabilities into operational programmes; and (3) the expansion of thinking to include polar orbiting as well as geostationary satellites. This expansion for CGMS was supported by the EC Panel of Experts and was an important goal to achieving the most effective use of the complete satellite sub-system by WMO Members.

The Chairman then summarized the recommendations from the EC Panel of Experts on Satellites whilst noting that the list was not in priority order. A summary of the final report, including recommendations, of the EC Panel of Experts on Satellites can be found in **Annex II**.

A.3 Drafting Committee

A Drafting Committee, comprising Messrs. G. Bridge (EUMETSAT), J. Giraytys (WMO) and C. Staton (USA) was appointed. CGMS members were requested to nominate a representative to provide inputs to this drafting committee.

A.4 Adoption of Agenda

CGMS agreed to add two additional items to the Agenda, A.7 - Extension of the responsibilities of CGMS and L.3 - Coordination of frequency allocations. The agenda (**Annex XVII**) was then adopted without further modification. The reader should note that the numbering of sections of this report correspond to those used in the Agenda. A list of Working Papers submitted to CGMS-XVIII can be found in **Annex III**.

A.5 Review of Actions from Previous Meetings

The Secretariat reviewed actions from previous CGMS meetings, as indicated on the next page.

i) Continuing Actions by All Parties

1. Circulation of satellite Operating Quarterly Reports

Status: Operations reports were being regularly distributed to all CGMS members.

2. Quarterly exchange of Photography

Status: Photographs had been exchanged.

3. Intercomparison of Extracted Winds

Status: Results of intercomparison carried out by USA in January 1989 had been distributed.

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

Status: Information had been sent by Members to NOAA when available. It was included in some quarterly operations reports. See also Section M.4.

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

Status: Information was being exchanged but on a rather irregular basis. See also Section F.1.

b) Status of Actions From CGMS XVII

ACTION 17.1 Japan to add EUMETSAT to the distribution list for GMS quarterly reports.

Status: Completed

ACTION 17.2 EUMETSAT to distribute Meteosat Quarterly Reports to CGMS members

Status: Completed

ACTION 17.3 CGMS members to provide comments on the draft of the eighth edition of the Consolidated Report within two months.

Status: Completed.

ACTION 17.4 The Secretariat to update and distribute the finalised eighth edition of the CGMS Consolidated Report to all members in due course.

Status: Completed. 8th edition was issued in April 1989.

ACTION 17.5 All CGMS members to study the information provided on the proposed Chinese FY2 transmission frequencies to ensure that there are no areas of possible interference, and to report to the Secretariat and to PTT authorities.

Status: Continuing. See Section L.3.

ACTION 17.6 The USSR to provide more information on the operation of experimental GOMS satellites at 14 degrees West and 166 degrees East and, if possible, to provide full details of transmission frequencies to be used during the experiments.

Status: Continuing. See section C.1.6

ACTION 17.7 PRC to provide more information on the bandwidth of frequencies used for HRPT image transmissions.

Status: Completed. See PRC-WP-1 and Section L.3.

ACTION 17.8 NOAA to investigate ways to transmit GMS and GOES West image data through the GOES East satellite.

Status: Completed. GMS WEFAX formats are transmitted through GOES-West and East.

ACTION 17.9 CGMS members to report on the progress with the setting up of EBBs at the next meeting of CGMS.

Status: Completed. See Section L.2

ACTION 17.10 USA to provide information on the management of its DCS processing system to CGMS members.

Status: Completed.

ACTION 17.11	USA to provide CGMS members with further information on the potential interference from vertical profilers.
Status:	Completed. See also Section F.1.2.
ACTION 17.12	EUMETSAT and USA to inform other members of CGMS when the new ASDAR code handling software has been implemented.
Status:	Completed. ASDAR code software has been developed.
ACTION 17.13	WMO to inform all CGMS members when ASDAR flight trials are expected to commence.
Status:	Completed. See also Section F.3.
ACTION 17.14	EUMETSAT to investigate if there are any problems with the adoption of a digitally encoded header for WEFAX transmissions and report to CGMS in due course.
Status:	Completed. See section G.1.2
ACTION 17.15	CGMS members to supply any information on interference to the DCS either to their SFCG representatives or to the CGMS Secretariat, in time for the next SFCG meeting.
Status:	Completed.
ACTION 17.16	USA to invite CGMS members, by 15 November 1988, to a digital WEFAX working group meeting to discuss the development of a common specification and the subsequent implementation plan for digital WEFAX.
Status:	Continuing. See Section G.1.4
ACTION 17.17	ESA to provide CGMS members with copies of papers produced by the ISCCP calibration centre.
Status:	Continuing.

ACTION 17.18 EUMETSAT to provide information to CGMS on the date and format of the ECMWF workshop on data assimilation, with particular emphasis being placed on the problems associated with the derivation of satellite winds.

Status: See Section I. In addition a Winds Workshop is planned for 29 June 1990, during the COSPAR meeting in The Hague, Netherlands.

ACTION 17.19 All CGMS members to determine what type of information relating to areas of deep convection is required by the data assimilation community and to report to the Secretariat within 6 months.

Status: Completed. Responses have been received from Japan and USA. See Section J.

ACTION 17.20 Japan to inform CGMS members on progress made with the development of new products and, where possible, to demonstrate their use in extended range forecasting methods.

Status: Completed. See Section I.3

ACTION 17.21 USA to brief CGMS on the use of VAS products at the next meeting of CGMS.

Status: Completed. See Section I.

ACTION 17.22 The Secretariat to include a new item in the agenda of the next CGMS meeting dealing with new products.

Status: Completed.

ACTION 17.23 The representative of CEOS to distribute to CGMS members the report of the work and tests performed by ESA/Earthnet on 12" optical disc data storage systems produced by various manufacturers.

Status: Completed.

ACTION 17.24 All CGMS members to consider the new format for working papers and if possible to implement the change in time for the next meeting of CGMS.

Status: Completed.

ACTION 17.25 All CGMS members to include a distribution list with any exchange of documentation

Status: Completed.

ACTION 17.26 WMO to confirm its willingness to host CGMS-XVIII

Status: Completed.

ACTION 17.27 The Secretariat to inform all members on the date and place of CGMS XVIII in due course.

Status: Completed.

A.6 Review of the Consolidated Report

Working Papers from Japan and WMO identifying corrections to the eighth edition of the CGMS Consolidated Report were noted by the meeting. The Secretariat agreed that these corrections, together with new information arising from CGMS-XVIII, would be included in a draft 9th Edition, which would be distributed to CGMS members during 1990.

Several Members of CGMS submitted revised lists of persons receiving CGMS documents. The Secretariat noted the changes.

A.7 Extension of the Responsibilities of the CGMS

CGMS Members proposed to extend the responsibilities of CGMS to include further discussion of planning, operation and use of polar meteorological satellites. CGMS considered that this could be achieved by an extension of the present informal objectives of CGMS and a change in its name to:

"Coordination Group for Meteorological Satellites"

A proposal was generated by the Secretariat during the Meeting (EUMETSAT-WP-24 refers) and CGMS Members were requested to review the proposal and to transmit any objections to the Secretariat within the next three months. If no objections were forthcoming by 1 April 1990 it would be assumed that the proposal should be implemented.

A copy of the proposal can be found in Annex IV.

Action 18.1 All CGMS Members to review the proposal to extend the responsibilities of CGMS and transmit any objections to the Secretariat within the next three months. If no objections are forthcoming by 1 April 1990 it will be assumed that the proposal should be implemented.

B. REPORT ON THE STATUS OF SATELLITE SYSTEMS

B.1 EUMETSAT

EUMETSAT WP-3 discussed the status of the Meteosat Operational Programme (MOP). Details of the Meteosat-4 launch, status of future MOP satellites and the upgrading of the Meteosat Ground Segment were presented. Meteosat-4 became operational, replacing Meteosat-3, on 19 June 1989. CGMS were also informed that Meteosat-5 would be launched in April 1990, and Meteosat-6 in the third quarter of 1993.

Action 18.2 EUMETSAT to inform CGMS on the altitude of ejection of METEOSAT-2 from the geostationary orbit.

B.2 India

A report on the status of the INSAT system was received by the Secretariat shortly after the meeting and can be found in **Annex V.**

B.3 Japan

Japan presented a report (WP-3) on the status of the GMS-3 VISSR observation satellite and informed the meeting that hourly full-disk image taking operations commenced on 5 January 1989.

In response to a question on grid/coastline jitter seen in GMS-3 WEFAX imagery, Japan reported that the problem was possibly caused by the high orbit inclination of the satellite (1.18 degrees).

Japan-WP-4 described the status of all the Japanese geostationary meteorological satellites. CGMS noted that GMS operations had stopped and the satellite deorbited on 30 June 1989. GMS-3 was currently the operational satellite, located at 140 degrees East. GMS-4 was launched at 1911 UTC, 5 September 1989, and will take over the operations of GMS-3 on 4 December 1989. The manoeuver to reposition GMS-4 began on 14 November 1989. The WP also contained an updated list of unexplained spacecraft anomalies.

B.4 People's Republic of China

A summary report on the First Flight Status of the Experimental Polar Satellite FY-1 was presented by the People's Republic of China (WP-2). The performance of the instruments and satellite structure was discussed. Although some degradation of the IR image data occurred, the failure of FY-1 was attributed to an attitude control system failure. The People's Republic of China also informed CGMS that, because of the relative success of FY-1, a replacement satellite FY-1B, is planned to be launched later in 1990.

B.5 USA

The status of both the GOES and NOAA satellite systems was presented (WP-2). The USA noted the failure of a Y-axis gyro on NOAA-11. A backup gyro was in use and the failure was determined to be random. A second gyro failure would likely result in a loss of attitude control and subsequent loss of the satellite. NOAA-9 is currently being used solely for ozone and earth radiation budget monitoring. NOAA-10 is operational with the exception of the ERBE and the 406 MHz Search and Rescue instrument. NOAA-11 is fully operational. NOAA-D is scheduled for launch in May 1990.

The current GOES configuration is as follows:

Satellite	Location	Major function
GOES-7	98W/108W	Imaging/sounding Stretched VAS relay
GOES-6	135W	WEFAX/DCS
GOES-5	65W	WEFAX/DCS Stretched VAS relay

B.6 USSR

The USSR informed the meeting that it was currently operating four meteorological satellites in near polar orbit: two of the METEOR-2 series and two of the new METEOR-3 series (a METEOR-3 satellite was successfully launched on 25 October 1989). These satellites will operate in tandem until the METEOR-2 series is replaced by the METEOR-3 series in 1992. The METEOR-3 satellites carry 10 channel radiometers including two channels for monitoring total content of ozone. It is intended that 2 or 3 operational satellites will be maintained in orbit at all times.

The representative of CBS noted that METEOR temperature profiles were not being transmitted over the GTS. The USSR stated that it would consider relaying the data over the GTS when the accuracy of the data had been improved.

Action: 18.3 USSR to provide Meteor-3 temperature sounding data over the GTS as soon as practical.

The USSR also operates satellites of the OKEAN (ocean) series. These satellites are launched regularly and are primarily used for gathering data on ice. The data are collected centrally in Moscow and then disseminated by television channels via the GORIZONT (horizon) communication satellites. Recently, the side-looking radar (SLR) on the current OKEAN satellite failed. The next satellite in this series is to be launched in 1990. The RESOURCE series of satellites also collect data which is used for a variety of purposes, including ice monitoring.

A brochure describing the technical characteristics of these satellite systems was made available to CGMS members at the meeting and is reproduced in **Annex VI**.

C. REPORT ON FUTURE SATELLITE SYSTEMS

C.1 Geostationary Meteorological Satellite Systems

C.1.1 EUMETSAT

a) The Transitional Meteosat Operational Programme (T-MOP)

EUMETSAT-WP-4 described the planning for an additional MOP-type satellite, called T-MOP, to fill a potential gap between the end of life of the Meteosat Operational Programme (MOP) satellites and the start of Meteosat Second Generation satellite operations. Options for the extension of MOP were described, including the manufacture and launch of an additional Meteosat satellite. Present planning indicated a launch date of T-MOP in the 1995/1996 time frame.

b) Meteosat Second Generation

In its WP-5 EUMETSAT reviewed the status of planning for Meteosat Second Generation (MSG). The meeting noted that following a re-definition of MSG missions to meet revised meteorological requirements, new payload instruments had been proposed. EVIRI, an enhanced imager with some sounding capacity, HRVIS, a High Resolution broad-band Visible Imager, and HSRS, a High Spectral Resolution Sounder, were described in the Working Paper, together with a brief summary of the two satellite design options, i.e. a spinner satellite and a three axis stabilised satellite. The meeting noted that the instrument payload would be selected by the end of 1991 and the provisional launch date of MSG was the last quarter of 1998.

C.1.2 India

A report on the status of future INSAT systems can be found in **Annex V.**

C.1.3 Japan

Japan reported that GMS-5 was scheduled to be launched in 1994 as the successor to GMS-4. The satellite will have an IR water vapour channel and a split window IR channel. GMS-5 is also planned to have the Search and Rescue function as a demonstration experiment. The current stretched VISSR data format of the GMS satellite series will be maintained with GMS-5.

C.1.4 People's Republic of China

PRC-WP-3 described the planning for the Chinese FY-2 Geostationary Meteorological Satellite System. FY-2, currently being developed by the Chinese Academy of Space and Technology, is a spinning satellite which will incorporate a VISSR as the primary instrument, a DCP relay, a WEFAX transponder and a space environment monitor (SEM). The ground segment is being developed by the State Meteorological Administration and comprises the CDA, SOCC and a Data Processing Centre (DPC). The various functions of these segments were also described in the WP.

C.1.5 USA

CGMS were informed that the new GOES I-M satellite system would put atmospheric soundings to operational use simultaneously with and totally independent of the imaging mission. Increased use of numerical data would be supported by new capabilities of the system. These important weather missions would be complemented by a SEM mission. Other mission requirements would include three additional services which would also be provided simultaneously and independently of the other services:

a) an interrogation and relay service for the rapidly expanding data collection platform operation;

b) a relay service of weather and GOES data satisfied by the concurrent WEFAX operation and the retransmitted processed data.

c) an operational Search and Rescue service, complementing the polar satellite operation.

Since the operational weather satellite programme had a history of adding or retrofitting new instruments into existing spacecraft, and the GOES I-M series were being designed to operate into the 21st century, the spacecraft bus would be capable of accommodating new instruments important to the overall mission.

The USA also reported on technical difficulties related to the development of the imager and sounder which in turn were partly related to the initial very stringent pointing accuracy specifications. These specifications had been relaxed to facilitate instruments development.

One major concern expressed by WMO was the impact of this relaxation on the accuracy of derived Cloud Motion Vectors. The USA recognized this point but indicated the full impact could not be assessed for the time being. The current launch date for GOES-I was planned for 1 June 1991.

C.1.6 USSR

The USSR informed the meeting that it planned to be ready to launch a geostationary meteorological satellite (GOMS) by the end of 1990. This operational satellite would be positioned at 76 degrees East and would carry instruments for general meteorological measurements. Data from the satellite would be received and processed in Tashkent. Direct readout from GOMS would be available in WEFAX format at 1691 and 1694 MHz. (For additional information on the GOMS satellites reference should be made to WMO Publication No.411).

CGMS recalled that the USSR had also requested equatorial positions of 14 degrees West and 166 degrees East respectively for 2 additional experimental geostationary satellites. It was noted that potential frequency interference might occur at these positions. The USSR informed the meeting that this issue was being actively pursued by the USSR Ministry of Telecommunications in co-operation with the International Telecommunications Union.

C.2 Polar Meteorological Satellite Systems

C.2.1 EUMETSAT

EUMETSAT-WP-6 provided a brief review of the current and future activities associated with the development of EUMETSAT Polar System (EPS). The short-term aim of these activities being to progress the accommodation of new meteorological instruments onto the ESA polar platform and to prepare a programme proposal on EUMETSAT Polar Systems. The meeting noted that the primary objective of EPS was the continuity of remotely sensed meteorological data from the morning (AM) polar orbit.

C.2.2 India

There was no report on this topic.

C.2.3 Japan

At present, Japan has no plan to launch a polar meteorological satellite. WP-6 presented the status of the earth observation satellite programme in Japan. These satellites are not meteorological satellites, but some data acquired by these satellites will be useful for meteorological research.

C.2.4 People's Republic of China

No working papers were presented on this topic.

C.2.5 USA

USA-WP-4 presented material on the plans for future polar-orbiting satellites in the NOAA series.

CGMS noted that the launch of NOAA-D was scheduled for May 1990. Although developed earlier, NOAA-D was not launched as originally scheduled because NOAA-E was ready for launch at the same time as NOAA-D and NOAA-E was equipped with the Search and Rescue system. NOAA-D had been called up for launch because of potential failures of current NOAA polar orbiting satellites. NOAA-D would fly in the 'AM' orbit and would thus not support the ozone monitoring function. NOAA-I (PM orbit) and NOAA-J (AM orbit) are scheduled for launch in 1991 and 1992 respectively.

The USA also informed CGMS that the NOAA-K, L, M series would not carry ERBE, SSU or MSU instruments. CGMS noted, however, that other operators were planning to fly Earth Radiation Budget instruments.

C.2.6 USSR

The METEOR-3 series, which will replace the METEOR-2 series satellites by 1992, will carry co-operatively developed instruments. A scanning earth radiation budget instrument is being developed in France to fly on a METEOR-3 satellite. The USSR will provide the calibration units, integration on the spacecraft and telecommunications links. Scientists from the Federal Republic of Germany are also providing assistance. The satellite is scheduled to be launched in August 1991. Data will be transmitted twice daily to Obninsk and Lannion.

A Total Ozone Monitoring Spectrometer may also be flown on a METEOR-3 satellite in the early 1990s. The United States will provide the instrument under a bilateral arrangement.

D. OPERATIONAL CONTINUITY AND RELIABILITY

D.1 Inter-regional Planning

D.1.1 Use of Meteosat-3 for Atlantic data coverage

CGMS took note of EUMETSAT plans to operate Meteosat-3 on a temporary basis, at a location near to 50 degrees West, to help provide essential data coverage over the Atlantic (EUMETSAT-WP-7 refers). It was hoped that the system could become operational by the end of 1989. The services to be provided by this satellite, were imaging, digital image dissemination, analogue (WEFAX) image dissemination and a limited image archive. Transmission formats and a preliminary dissemination schedule for Meteosat-3 images had been generated (see section G.1.1).

D.1.2 INSAT Relay - Status report

CGMS was informed, in EUMETSAT-WP-8, that over recent months the possibility of relaying INSAT image data via Meteosat had been studied further. In order to progress this matter a meeting had taken place with the Indian Ministry of Science and Technology and the Meteorological Service of India. The main outcome of this meeting was the setting up of a feasibility test of the relay over a period of approximately three months. Permission to proceed with the implementation of the test was still awaited from the Indian authorities. It was agreed, however, that during the test, full disk images in VIS and IR would be relayed, at 00, 06, 12, 18 UTC for IR and at 06 UTC for VIS. Images would be available within 2 hours of acquisition, and would be relayed to ESOC via a duplex INTELSAT data link.

CGMS regretted the lack of real progress being made with the implementation of an INSAT relay. CGMS also recalled that it had been agreed that some INSAT image data tapes would be made available to members for analysis, via the WMO. WMO confirmed that details of the acquisition of tapes had been discussed with India and steps were being taken to try and have them mailed to the WMO.

Action 18.4 **WMO to continue its efforts to acquire INSAT image data tapes.**

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

D.1.3 Upgrade of the GOES Meteosat Relay

In its WP-9, EUMETSAT informed the meeting about an upgrade of the GOES METEOSAT Relay (GMR) Equipment, operated at the "Centre Meteorologique Spatial" in Lannion, France. The WP also provided details of additional services possible with the new equipment. CGMS noted that one of the tasks to be performed by the new equipment was the processing of GVAR image formats to be transmitted from the next series of GOES satellites. NOAA-NESDIS confirmed that a GVAR simulator card would be sent to EUMETSAT in the near future to allow testing of relevant hard and software in advance of operational transmissions. The USA informed the meeting that some test transmissions of GVAR were planned using GOES-5 and GOES-6 as relay satellites.

D.2 Global Planning

CGMS remarked that following the successful launch of GOMS, FY-2, GMS-5, the Indian ocean region would be well covered by meteorological satellites in geostationary orbit. Furthermore, with GOES-Next, METEOSAT, GOMS, FY2 and GMS-5, total world-wide coverage would become a reality. Members considered, therefore, that it might be useful, already at CGMS XIX, to discuss optimisation of the location of all future geostationary meteorological satellites and to indicate possibilities for contingency planning.

D.3 Commonality of standards

No papers were presented on this topic.

E. GEOSTATIONARY SATELLITES AS PART OF WMO PROGRAMMES

E.1. World Weather Watch

E.1.1 Status of Planning for the OWSE-Africa (OWSE-AF)

The WMO gave a status report on the implementation of the OWSE-AF. The purpose of Operational World Weather Watch Systems Evaluations (OWSE) is to evaluate, under field conditions, the impact of introducing new technology into the WWW. The first OWSE was on the North Atlantic and focused on improvements to the Global Observing System (GOS). The final report of this OWSE was in preparation and would be presented to CBS at its meeting in September 1990.

The second OWSE to be organised is for Africa. The first phase of the OWSE-AF concerns the improvements which could be made to the availability of meteorological data by using the DCS and DCP Retransmission System of the Meteosat satellites. In total, some 50 DCPs and 15 DRS receivers will be installed in 14 countries. Once installed, an evaluation will be conducted to examine (1) the performance of the hardware and software, (2) the exchange of information through the satellite, (3) the availability of the data at National Meteorological Centres and main processing centres both in and outside of the Region and, (4) the supporting services needed to make the equipment work as a reliable augmentation to the GTS.

The CGMS was informed that the implementation of equipment had started in May 1989 and was expected to be completed by May 1990. At present the DCPs in Ethiopia and Kenya had been installed and installation was in progress in the Sudan. The last of the DCPs would be installed in Ghana during February 1990. Other countries, such as Sierra Leone, Liberia, Nigeria, Zaire and Somalia, would have their DCPRS receivers installed at the beginning of February 1990.

The WMO informed CGMS that one major equipment problem had been encountered and that was with the time drift on many of the DCPs. Over half of the DCPs drifted outside the limits within a few days to one or two weeks. A retrofit of new crystals had started in Ethiopia, but the replacement crystals were also not usable in several instances. A major effort was now being planned to ensure that all of the DCPs stayed within allotted time limits.

The evaluation programme had begun and included support from EUMETSAT in monitoring the performance of the DCPs. Early monitoring had uncovered a number of operational difficulties, some of which had already been resolved. The WMO noted that it was particularly important to ensure continuous and reliable operation of the DCS since this service was now being relied upon as an operational augmentation to the GTS. In this regard the WMO noted that there had been several unfortunate disruptions to the DRS during the implementation in both Ethiopia and Kenya. The problems had been handled promptly after notification and the WMO thanked EUMETSAT and ESA for their substantial assistance and contributions to the OWSE-AF.

CGMS noted that phase II of the OWSE-AF would consider the MDD mission. EUMETSAT informed the meeting that the two existing MDD receivers would be placed at several locations in Africa for a demonstration and early evaluation of the capabilities of the system. CGMS remarked that it would be useful if these early demonstrations and evaluations could be conducted under the framework of the OWSE-AF. WMO agreed that it would provide all appropriate assistance and suggested that a letter be sent from EUMETSAT to the WMO with suggestions on how to initiate the activity.

Action 18.6 **EUMETSAT to consult with the WMO on the procedures for the inclusion of the MDD in Phase II of the OWSE-AF.**

E.1.2 Satellite evaluations

The CGMS discussed the advantages of conducting an evaluation which could be considered as an OWSE on satellites. During these discussions CGMS was informed of the recommendation by the EC Panel of Experts on Satellites that an OWSE should be organized through CBS concerning specific aspects of the satellite programme. Note was made, for example, of (1) the changes which were being made to the sensors on the polar orbiting satellites and which would be operational during the mid 1990s, (2) the need for meteorological services to be in a position to use the information from these new sensors, (3) the need to have better and more widespread use made of the existing data from meteorological satellites, (4) the need to advise meteorological services, particularly those from developing countries, on the performance characteristics of local user terminals and (5) important activities which had already been started concerning these issues.

The CGMS strongly supported the recommendation of the EC Panel of Experts on Satellites to organize an OWSE-Satellite. It suggested that major consideration be given to (1) the better use of existing information, (2) developing guidance on the performance characteristics of a minimum work station suitable for satellite data and related products, and (3) developing recommendations on how to prepare for the coming changes in satellite capabilities.

E.2 Other programmes

No papers were presented on this topic.

F. CO-ORDINATION OF DATA COLLECTION

F.1 Status and Problems of the IDCS

F.1.1 JAPAN

Japan-WP-7 and 8 reported on current knowledge of the utilisation of DCS channels. Some instances of messages being lost were noted, caused primarily by the incorrect use of DCP equipment. In addition, for the Syowa station in Antarctica, reporting through Meteosat, only about 80% of messages transmitted from the station were being received in Japan via the GTS.

Action 18.7 EUMETSAT to monitor the relay of messages of Syowa to Japan Meteorological Agency.

CGMS agreed that more regular co-ordination of IDCS channel assignments was necessary and the Secretariat agreed to create the necessary data base, and to study a data format allowing the exchange of files on diskette between members.

Action 18.8 CGMS members to provide, on a quarterly basis, listings of IDCS channel assignments to the Secretariat.

Action 18.9 The Secretariat to co-ordinate inputs made by members on IDCS channel assignments and provide consolidated listings to members on a quarterly basis.

Action 18.10 The CGMS Secretariat to send all available information on the IDCS to the People's Republic of China and USSR.

Action 18.11 People's Republic of China and USSR to inform the Secretariat when IDCS channels will be implemented.

CGMS also noted that there was some external interference to some national regional channels.

F.1.2 USA

The USA provided an information paper (WP-22) on the planned use of wind profilers (radars) for meteorological information collection and the necessity for coordinating their frequency band in order to avoid conflict with other U.S. National and International programmes. It was noted that the proliferation of such profilers operating within the frequency band 400-406 MHz should be avoided. The USA is working to change the National Table of Frequency Allocations. The USA is also investigating the use of the international frequency band 420-425 MHz (as supported by SFCG) as a solution to the potential conflict.

Action 18.12 USA to initiate the action by a letter to the Secretary-General including a rationale why profilers could be classified as radio location systems.

Action 18.13 WMO to notify all Members accordingly.

F.2 Ships, including ASAP

F.2.1 JAPAN

Japan, in WP-8, informed CGMS on the status of ship DCP transmitting messages through GMS-3. CGMS took note of the DCP assignments to IDCS channels I12, I14, I15, and I16, and to local ships using regional channels R6, R7, R8, R9 R11, and R12.

Action 18.14 The Secretariat to include the information in the consolidated IDCS assignment reports and to consider the use of ASCII data formats to allow exchange of information between CGMS members on diskette.

F.2.2 WMO

CGMS was informed that 16 ASAP systems were now in operational service, three on the North Pacific and the remainder on the Atlantic Ocean. In addition, an ASAP system had been installed on Kanton Island as part of the TOGA programme. WMO noted that two additional systems would be made operational during the coming year and that a further two systems were being considered. The ASAP programme was now considered to be a fully operational part of the GOS. Following the launch of Meteosat-3 in mid-1988 an end-to-end test of ASAP data exchange and its receipt at processing centres had been conducted. Major data losses were discovered. The situation was improved somewhat after the launch of Meteosat-4 and as a result of changes which were made in the data processing procedures at the ground station. A second special monitoring was conducted in early 1989 which showed that in some cases as much as 70% of the data were being lost in the total system. The results varied considerably by day and sometimes by ship.

At the request of the ASAP Co-ordinating Committee (ACC), a major end-to-end test was organized by the WMO to include each of the satellite operators, the operators of the ASAP systems and the main telecommunication and data processing facilities in France, Federal Republic of Germany, the U.K., the USA, the USSR, Japan and Australia. The test period began on 1 October 1989 and will be completed on 30 November. This test includes a comparison of logs kept by the ship's personnel and logs kept by each of the above participants. The data analysis will be done by the Weather Service at Hamburg. The results are expected to be available in early 1990. CGMS noted that early results showed that data reception rates for some ships was now in excess of 90% and that this indicated a substantial improvement.

Action 18.15 The WMO to provide the CGMS Secretariat with the results of the ASAP end-to-end test and indicate what action, if any, the CGMS should consider to improve the availability of ASAP data.

The WMO then presented a paper concerning the requirements for additional time slots for the ASAP. It was pointed out that the current channels assigned to ASAP were nearly full and that additional systems were expected to be implemented during the coming year. Additionally, there was the need to ensure that sufficient time slots were available for (1) the complete message, that is parts A, B, C, and D, and (2) additional soundings at 06 and 18 UTC. At present, some of the part B messages, which include the significant levels, had to be abbreviated to fit into the time slots assigned. There was the necessity for either longer time slots or the assignment of adjacent time slots to ensure that the full messages were received properly. The CGMS was informed that one of the recommendations of the OWSE-NA was to increase the frequency of soundings from ASAP ships to include either or both 06 and 18 UTC and that some of the operators were seriously considering the possibility of making additional soundings.

A draft proposal for the allocation of additional time slots had been prepared by the ACC and was presented by the WMO.

CGMS agreed in principle to the allocation of additional time slots for ASAP, but noted that the implementation would have to be closely co-ordinated with the satellite operators and the ACC which acted on behalf of the ASAP operators.

Action 18.16 The CGMS Secretariat to work out an implementation programme with the ACC and the WMO Secretariat for allocating additional time slots to the ASAP.

Action 18.17 Satellite operators to work with the CGMS Secretariat (1) to open the necessary channel, (I10 proposed), (2) to monitor the channel to be certain that it would be usable and (3) to agree on time slot and channel assignments for ships, including ASAP.

F.3 ASDAR

F.3.1 USA

The USA provided information on the status of its participation in the ASDAR programme(WP-8) and indicated that it was ready to participate in the FAA certifications now expected to be carried out early in 1990.

Both EUMETSAT and USA confirmed that programming effort to decode messages using the WMO Code FM 42-IX from the operational ASDAR units had been completed.

F.3.2 WMO

WMO gave a report on the status of the ASDAR programme. Five of the original prototype systems built for the FGGE were still in operational service. Over recent months, EUMETSAT had received approximately 1000 reports per month from these units.

The first ASDAR operational unit had been fabricated and had passed IDCS certification. The unit had also passed all of the environmental and related testing on the ground. The documentation had been submitted in October 1989 to the Civil Aviation Authority (CAA) in the U.K. as part of the application for CAA certification. The CAA had yet to decide if a flight test would be required before granting certification. A decision was expected by mid-December.

Two aircraft belonging to British Airways (a Boeing 747 and DC-10) had been equipped to carry ASDAR units. It was expected that either of these aircraft could be fitted with the ASDAR units within a few weeks of the CAA decision on the certification.

Certification through the Federal Aviation Administration (FAA) in the United States would be carried out by Continental Airlines. The final arrangements were being made by the contractor for these certifications on both Boeing 747 and DC-10 aircraft.

As agreed at CGMS-XVII, Continental will participate in a three month flight trial of the ASDAR. This trial is required as part of the contract with the WMO prior to final acceptance of the ASDAR systems. During this period, two sets of meteorological data will be transmitted by the aircraft. One set will be the normal ASDAR data set and these will be exchanged on the GTS. The other set of data will be taken directly from the aircraft avionics without being processed using ASDAR algorithms. This latter set will be transmitted by the ASDAR in a separate time slot, but will not be exchanged over the GTS. Both sets of data will be used by analysts in the U.K. to evaluate the ASDAR data processing algorithms. A centre at the U.K. Meteorological Office will also compare the ASDAR data with analyses used in numerical models.

CGMS was informed that the contractor had started production of the remaining 12 units in the initial order so that deliveries could be started as soon as the three months flight trials had been completed. Note was made that the software had been completed for the automated formatting of the ASDAR data, but that it would be valuable to test this software before the first operational ASDAR systems were flown. It was agreed that a test of the software would be arranged by the WMO and EUMETSAT.

Action 18.18 The WMO and EUMETSAT to arrange ASDAR test transmissions through the Meteosat satellite system.

Action 18.19 The WMO to complete the procedures for the three month flight trial and to inform the CGMS members.

Action 18.20 The WMO to inform the CGMS Secretariat when the first ASDAR systems will be reporting in time for the ground software to be activated.

F.3.3 JAPAN

Japan reported (WP-9) on the status of its ASDAR programme. Arrangements for the automated formatting of the ASDAR data were completed.

F.4 Review of IDCS Users' Guide

CGMS recalled that the 6th edition of the International Data Collection System (IDCS) Users' Guide had been distributed in January 1988. Members were invited by the Secretariat to inform it of any errors in the document and to indicate where information required updating. CGMS were informed that the document would be revised in 1990 to reflect any amendments and to incorporate new material resulting from CGMS-XVIII.

G. CO-ORDINATION OF DATA DISSEMINATION

G.1 Dissemination via Satellite

G.1.1 High resolution

EUMETSAT-WP-11 described changes made recently to the Meteosat High Resolution and WEFAX dissemination services, the most significant being the adoption of the international WEFAX channel frequency (1691 MHz) for Low Resolution WEFAX image dissemination. At the same time high resolution image dissemination was moved to 1694.5 MHz and a new dissemination schedule was introduced.

In its WP-12, EUMETSAT described the initial dissemination schedule for METEOSAT-3 from its position at 50 degrees West. CGMS noted that this paper complemented EUMETSAT-WP-7 - Use of Meteosat-3 for Atlantic Data Coverage (see Section D.1.1.).

CGMS expressed its appreciation of the efforts being made by EUMETSAT to provide an Atlantic area image dissemination service in support of the Global Observing System.

Japan WP-10 presented the current GMS stretched VISSR and WEFAX dissemination schedule which was implemented on 5 January 1989. This schedule now included hourly full disk images.

G.1.2 Low resolution (WEFAX)

USA WP-9 and EUMETSAT WP-14 discussed the issue of a computer readable code in the analogue header of the WEFAX images. Both papers were in agreement that a simple format standard should be adopted. The Chairman recommended the setting up of a splinter Working Group to discuss details of these proposals. The USA, EUMETSAT, Japan and the People's Republic of China participated in the Working Group. Japan expressed concern over the adoption of a standard because it was already transmitting a computer readable code and any changes to this code would affect many WEFAX users. The Working Group recognized the impact of such a change and agreed to include the problem of implementation or a code in its recommendations. The USSR added that it would consider implementing the code recommended by CGMS.

The Working Group submitted the following proposal for a standard header format:

SAT-ID	SPECTRAL BAND	DATE	TIME	SECTOR	OPEN
		YYMMDD	HHMM	ID	
8 char	3 char	6 char	4 char	4 char	25 char

Notes:

a) Each character (char) is coded in ASCII (most significant bit first). The ASCII characters are from the approved characters of the International Alphabet number 5 as defined in the IDCS Users' Guide Annex 4. Each character will be coded into 8-bits.

b) Each bit will be 2 pixels wide in reference to an 800 pixel WEFAX line (1 = white, 0 = black).

c) The coded line will be transmitted a minimum of 2 times.

d) All information is left justified in each field (blank filled with ASCII 'space').

e) The coded header will start immediately after the WEFAX line synchronisation.

f) The open characters may be coded with any ASCII character as defined in a) above by the operator. These may also be omitted.

Action 18.21 Members to inform CGMS Secretariat by 1 April 1990 if this format is acceptable. Failure to notify will constitute acceptance.

Action: 18.22 CGMS Members to provide details of the expected date of implementation and the information contained in each field at CGMS XIX.

G.1.3 DCP Data

G.1.3.1 EUMETSAT

EUMETSAT informed CGMS, in WP-13, of plans to more actively promote the Meteosat DCP service and to improve services to users. A possible co-operation with CLS/ARGOS, to expand data collection and distribution services for non-meteorological users in particular, was presently under consideration.

The USA informed the meeting that it had also been approached by CLS/ARGOS with a similar offer to promote DCS services to users.

CGMS recalled that DCS frequencies could only be allotted for the collection and relay of environmental data.

EUMETSAT confirmed that although the proposal referred to non-meteorological services, it was only environmental data that would be handled by CLS/ARGOS.

G.1.3.2 USA

The GOES DCS Automated Processing System (DAPS) became operational on 18 October 1989. USA-WP-10 provided an overview of the DAPS and highlighted some of its advantages over the previous DCS computer system. With the commissioning of DAPS in October 1989, the only remaining constraint on the GOES DCS system was the radio frequency front end, currently scheduled for refurbishment by late 1990.

G.1.4 Digital WEFAX

The USA informed the meeting that its WP-11 was submitted to CGMS in response to an earlier action. There were currently no plans to develop a standard for digital WEFAX in the USA. The USA remarked that the introduction of such a transmission scheme would have to be announced well in advance, to allow users time to convert ground station equipment.

EUMETSAT informed the meeting that it intended to develop a digital WEFAX dissemination scheme for its future satellite systems. A study to determine a suitable coding scheme, data rate, format etc., would be completed in 1990.

Action 18.23 EUMETSAT to report on the progress made with the development of a standard for digital WEFAX to the next meeting of CGMS.

CGMS endorsed the efforts being made by EUMETSAT to develop a digital WEFAX scheme, and both the People's Republic of China and USSR strongly supported the activity. They informed CGMS that they were considering the introduction of digital WEFAX services on future geostationary meteorological satellites and would be willing to adopt a common format. The USSR also remarked that it was studying the possibility to relay digital APT from its polar orbiting meteorological satellites using the 1.7 GHz frequency band.

CGMS stressed the need for analogue and digital WEFAX services to exist in parallel for a considerable numbers of year to allow the user community ample time to convert from one system to the other.

G.2 Dissemination via GTS

CGMS noted that the Japan Meteorological Satellite Centre (JMA) operationally disseminated reports on tropical cyclones (SAREP) when a tropical cyclone was located in the region between 100 degrees East and 140 degrees East in the Northern Hemisphere. This region would be extended to 100 degrees East to 180 degrees East from November 1989 (Japan-WP-11 refers).

G.3 Other dissemination

In WP-15, EUMETSAT presented a status report on the implementation of the Meteosat Meteorological Data Distribution (MDD) mission. A demonstration broadcast, transmitted from an uplink station in Bracknell, U.K. was expected to commence during December 1989 and the second uplink station in Rome, Italy, was expected to become operational by the end of January 1990.

The meeting noted that demonstrations of the MDD system were planned at several locations in Africa during 1990.

CBS requested that there also be a demonstration of MDD at the extraordinary session of CBS, being held in London, U.K. from 24 September to 5 October 1990.

CGMS was also informed (EUM-WP-22) that the European Centre for Medium Range Weather Forecasting (ECMWF) plans to receive and process ERS-1 data on an operational basis and to provide access to ERS-1 data to ECMWF Members States. The Working Paper provided a summary of the final report of the ECMWF Council Working Group on ERS-1 data, which met at ECMWF, Reading, in June and July 1989. ERS-1 data requirements, format and transmission schemes were elaborated at these meetings.

H. CO-ORDINATION OF SATELLITE DATA CALIBRATION

Information on the Meteosat calibration mechanism and methods of absolute calibration was provided by ESA (**Annex VII**).

I. CO-ORDINATION OF METEOROLOGICAL PARAMETER EXTRACTION

I.1 Satellite Winds

ESA presented details of the new Meteosat Cloud Motion Vector (CMV) processing scheme which had become operational in March 1989. The scheme, which involves the use of forecast winds to determine the starting point of the correlation surface calculation, has shown a noticeable improvement in the speed bias of high level winds. An information paper was distributed at the meeting (**Annex VIII**).

Japan informed CGMS that it had now extended its processing area for cloud motion wind extraction at 06 and 18 UTC from the northern hemisphere to both hemispheres (WP-13).

CGMS also noted that Japan was deriving low level CMV in a typhoon area on a routine basis using 15-minute interval images during the 1988 typhoon season. The Paper (WP-14) showed that the resultant CMVs outside a circle some 200 km from a typhoon centre were useful data, that the mean direction of the ship observation winds were backed by about 30 degrees from CMV direction and that the mean speed of CMV was almost equal to that of ship observed winds.

Action 18.24 Japan to provide details on the estimation of ocean surface winds in a typhoon area from GMS images.

Action 18.25 Japan to determine if typhoon CMV information can be relayed over the GTS.

CGMS noted that the 15 minute image taking sequence interrupted the nominal schedule, and that the users were informed of these changes in the schedule via disseminated administration announcements and, whenever possible, in advance of the event.

CGMS were pleased to note the increase in the total numbers of derived CMV each month, especially with effect from January 1989, resulting from an extension of the processing area to include both Northern and Southern hemispheres at 06 and 18 UTC (WP-13).

Statistics of monthly means of vector difference between GMS winds and radiosonde winds were also presented. In WP-13 CGMS also noted that the vector differences of these winds were calculated in the same way as the International Comparison of Satellite Winds, and that the comparison was made 4 times a day. The mean of the vector difference and the Root Mean Square (RMS) were almost the same as those from previous years.

The USA informed the meeting that in compliance with the decision of CGMS to conduct a semiannual International Comparison of Satellite Winds, its WP-12 reported on the July 1989 wind comparison. The comparisons were of two types: type 1, satellite-to-satellite wind differences, and type 2, satellite-to-rawinsonde differences.

CGMS noted that because of the loss of GOES-6, there were no satellite-to-satellite comparisons with GMS. GOES-7 was stationed at 108 degrees West until the end of June, when it was moved to 98 degrees West. As a consequence there were a very limited number of satellite to satellite comparisons made with Meteosat winds. The USA informed the meeting that one page of the statistics was missing from the WP-12.

Action 18.26 USA to distribute missing wind statistics information to all members of CGMS.

CGMS recalled that one difficulty in making true comparisons of wind was the fact that totally different wind extraction schemes were being compared. The Group considered that a 6 month interval for Type 1 comparisons seemed appropriate, however, Type 2 comparisons should be more frequent and should show the evolution of wind quality on a monthly basis in order to show trends rather than snap shots.

CBS urged the satellite operators to co-ordinate efforts to improve extracted wind quality and to exchange results on a more frequent basis.

Action 18.27 CGMS members to include Type 2 data on a monthly basis in quarterly reports.

In USA-WP-12 CGMS noted that NESDIS cloud motion wind data sets now covered an area from 60N to 60S.

USA-WP-14 summarised NESDIS efforts to improve the quality of the operational satellite winds. CGMS noted with interest the use of the 13.3 um carbon dioxide channel information in the algorithms used for the extraction of cloud motion vectors.

Action 18.28 USA to provide CGMS with more details of its new wind extraction method.

USA reminded CGMS that the authors of its Working Papers could be contacted directly for information (**Annex IX**).

In USA-WP-15, CGMS noted that weekly collocation statistics and wind plots were being routinely produced to aid the quality control of NESDIS winds.

EUMETSAT-WP-23 identified a significant improvement in the quality Meteosat CMV during the year and discussed possibilities for other satellite operators to share experiences more closely in order to improve the quality of CMV on a global scale in order to promote their wider use in medium range forecasting schemes.

The use of a standardised statistic, such as the ratio of wind bias to speed, to obtain smoother verification results, was recommended. An example of the statistic for Meteosat winds was presented.

WP-23 made proposals for the following joint actions:

a) A scientific session on CMV within COSPAR 90

b) A winds comparison campaign over the Atlantic using Meteosat-3 image data as a common source of information to compare European and USA wind extraction methods

Action 18.29 EUMETSAT to provide members of CGMS with the COSPAR meeting Announcement.

EUMETSAT-WP-16 summarised the results of a joint ECMWF/EUMETSAT workshop on "The use of satellite data in Numerical Weather Prediction (NWP)", held in Reading, U.K., during May 1989. The purpose of the workshop was to review the quantitative use of satellite data for NWP, particularly in the medium-range, and to discuss the possibilities for better exploitation of wind, temperature and humidity data from current and future satellite systems.

CGMS commented that the quality of models had improved significantly over the last 10 years, but these improvements had not been matched by corresponding improvements in all satellite derived data products. Furthermore, the impact of satellite sounding information on numerical forecasting schemes was presently inconsistent. The impact was small on occasions in the Northern Hemisphere in locations where there was an abundance of other observation data. However, in data sparse areas, especially in the Southern Hemisphere, there was always a positive impact of sounding data on NWP schemes.

CGMS also noted that there was now a general feeling that not only should the quality of derived satellite data be improved further, but that better use of the basic (raw) data should be investigated by the modellers. The Group remarked that satellite sounding products were very different from radiosonde soundings, and as a consequence should be treated in a different way. CGMS noted that EUMETSAT and ECMWF had agreed to establish a research activity at ECMWF to address in particular the problems of data assimilation, and to define requirements for new satellite products, based on the needs of modellers. CGMS agreed that the recent improvements in the quality of CMVs should be brought to the attention of the modelling community. Attention should also be paid to increasing the vertical resolution of sounding information. CGMS commented that since a satellite system could have a 20 year lifetime, instrument design and observation quality might often lag current requirements. However, the real value of improved satellite data might be in the domains of mesoscale forecasting and nowcasting.

Japan remarked that some observations of smaller scale features (e.g. aircraft observations of typhoons) were no longer available, and the forecasting of this scale of feature required remotely sensed data.

CBS reminded CGMS that information on new products and improvements in existing products should be provided to WMO designated lead centres. There was a need for regular exchange of information, using conferences, workshops, observation campaigns, etc.

EUMETSAT suggested that participants to the COSPAR workshop, being held on 29 June 1990 in The Hague, should discuss the setting up of an international wind retrieval group, and its reporting mechanism. EUMETSAT could take an action to lead the discussions on this issue. CGMS agreed that COSPAR would provide an excellent forum to bring together a wide group of experts on this subject. EUMETSAT informed CGMS that a group of European experts had already been identified, however a future framework could be established which would become more international in character.

EUMETSAT could also propose future actions, following the COSPAR workshop. It proposed to announce the formation of the group and invite participation. CGMS members or designated experts would be encouraged to participate in the COSPAR meeting and to support the setting up of the group.

All CGMS members agreed to investigate possibilities for participation in the COSPAR meeting and follow on activities.

Action 18.30 **CGMS Secretariat to provide information on satellite products to the relevant WMO designated lead centre, on a regular basis.**

Action 18.31 **EUMETSAT to arrange that the setting up of a CGMS sponsored International Winds Retrieval Group be an agenda item of the COSPAR Winds Workshop, and to provide draft terms of reference for the group.**

I.2 Sea surface temperatures

No papers were presented on this topic.

I.3 Other parameters

Japan-WP-15 described the derivation of a Satellite-derived Index (SI) of Precipitation Intensity which was calculated automatically on an hourly basis and used by the Forecast Division of JMA. CGMS noted that although the SI had been produced routinely since 1 March 1989, it had not yet come into operational use for short range forecasting.

The USA informed the meeting that it interactively produced a similar product for heavy precipitation on an as required basis.

The USA also provided an information paper (WP-16) on tropical rainfall investigations being carried out under the Global Precipitation Climatology Project. CGMS noted that EUMETSAT and Japan were also producing similar products.

In WP-17 the USA briefly described the meteorological products developed from the VISSR Atmospheric Sounder (VAS).

Action 18.32 The USA to provide information describing VAS products to CGMS-XIX.

I.4 New products

Japan-WP-16 reported on the use of Cloud Amount Anomaly data in the long-range forecast division of JMA. These were mainly used to monitor convective activity in tropical regions.

J. USE OF SATELLITE PRODUCTS IN NUMERICAL WEATHER PREDICTION

In response to discussions on deep convection at CGMS-XVII, Japan (WP-17) provided a proposal for a new product (**Annex X**).

In its WP-18, the USA proposed a list of possible new products for use in numerical weather prediction (**Annex XI**).

USA-WP-19 provided information on the anticipated products from the NOAA polar orbiting satellites in the K, L, M era. A detailed list of approved products was provided (**Annex XII**).

Action 18.33 CGMS members to ascertain if there is a general requirement for these new products.

K. CO-ORDINATION OF ARCHIVING AND RETRIEVALS

In response to a question concerning recent developments with optical disk storage systems, ESA informed the meeting that it had discontinued further study for the time being. Present indications on costings indicate that this data storage system is still about 3 times the cost of tape or cartridge systems. ESA had started to use a cartridge data storage system, mainly on the grounds of improved storage to volume efficiency.

Action 18.34 USA to inform CGMS on the planning of the new archive storage system for its future GOES satellites at CGMS XIX.

(The names and addresses of points of contact for the procurement of archived data can be found in **Annex XIV**).

L. TELECOMMUNICATIONS

L.1 General

Protection of the 2 GHz band

In its WP-17, EUMETSAT drew the attention of CGMS members to a potential interference caused by the use of the 2 GHz frequency band by "Mobile Services". CGMS Members were informed that the impact upon programmes of many space agencies would be significant and, in particular, most meteorological satellite projects could be affected.

CGMS, noting that this issue was already the subject of a Resolution from SFCG 9, strongly supported the protest action recommended by EUMETSAT. CGMS agreed the following actions:

Action 18.35 EUMETSAT to provide CGMS members with the references of CEPT documents referring to the protection of the 2 GHz frequency band.

Action 18.36 WMO to prepare an information paper for submission to WARC 92 on the protection of the 2 GHz frequency band.

Action 18.37 CGMS members to raise the issue of the protection of the 2 GHz frequency band with national PTT representatives.

EUMETSAT WP-17 provided a summary report of the 9th meeting of the Space Frequency Co-ordination Group (SFCG), which was held in Kiruna, Sweden, during the latter part of August 1989. The Group were reminded that the primary objectives of this international working group were the co-ordination of frequency requirements for future spacecraft systems and the protection of allocated frequency bands.

CGMS in particular noted the discussions dealing with the upgrade of frequency allocations in the band 401-403 MHz, the potential interference from wind profilers, the protection of distress frequencies, candidate frequency bands for space station proximity links, and the maintenance of meteorological satellite frequency bands.

CGMS noted with satisfaction the ongoing activities of the SFCG and commented that this group, although (like CGMS) informal in its constitution, produced important recommendations and resolutions.

In its WP-7, WMO informed CGMS about a submission to the next ITU Administrative Conference in order to improve the protection of the DCS against harmful interference. The WMO Study Group on Communication Techniques and Protocols had reviewed this matter at its fourth session, held in May 1989, and had requested the WMO Secretariat to send a letter to WMO Members with a view to:

(a) including the allocation in the band 400.15-406 MHz in the agenda of the next world Administrative Radio Conference (1992);

(b) initiating the preparations for a consolidated proposal through co-ordination between WMO Members, CGMS, CIMO and CBS.

CGMS noted a copy of the letter **(see Annex XIII)** attached to the Working Paper and requested that CGMS members bring it to the attention of their National PTT authorities, representatives and frequency managers.

Action 18.38 CGMS members to ensure that the letter prepared by the Secretary-General of the WMO on the subject of the allocation of frequency to data collection services of meteorological satellites is brought to the attention of their national PTT authorities, representatives and frequency managers.

L.2 Electronic Bulletin Board (EBB)

EUMETSAT-WP-19 informed CGMS that planning had commenced for the installation of an EBB which would operate in complement with the EBB successfully developed by NOAA/NESDIS (USA-WP-6 refers). The system proposed would be a read only system, although a read/write facility would exist between EUMETSAT and other CGMS EBB operators. Users would pay normal PTT connection charges to access the EBB. EUMETSAT had no plans to levy any administrative access charges.

CGMS suggested that a standardized subset of bulletin boards, which could be supported by all CGMS Members operating an EBB, should be a feature of the system.

Noting that Japan had not yet decided to set up an EBB, USA informed the meeting that it would be pleased to place GMS information on its own EBB.

Action 18.39 Japan to study the feasibility of developing an EBB.

Action 18.40 People's Republic of China to provide the Secretariat with details on telecommunication networks in its country.

Action 18.41 USA and EUMETSAT to submit a standardized subset of bulletin boards, which could be supported by all CGMS Members operating an EBB to the secretariat by 1 February 1990.

Action 18.42 EUMETSAT to provide USA with details of its stand-alone PC based EBB system.

L.3 Co-ordination of frequency allocations

L.3.1 Possible interference

L.3.1.1 FY-2

Japan noted in its WP-1 that there might be a problem of interference between certain transmission frequencies of the Japanese and Chinese geostationary satellites. Particular attention was focused on the transmission frequencies for DCPs and secondary user stations. CGMS noted that the agreed plan for the use of the DCP frequencies included dividing that part of the bandwidth from 401.5 to 402.2 allocated to the domestic regional channels in such a way that there was either a geographical or frequency separation between the GOES, GMS, Meteosat and GOMS satellites. CGMS agreed that the operation of the FY-2 satellite would not cause a problem for the transmission of DCP reports since China intended to use the band at 401.0 to 401.5 MHz, thus assuring a frequency separation from the other satellite transmissions.

Interference might occur, however, if interrogated DCPs were to be used by more than one country, such as in a Tsunami warning programme. The meeting noted that China had applied for use of the DCP interrogation frequencies after the applications of both Japan and the USSR. Japan and China agreed to perform studies of potential interferences and to exchange study results for evaluation. Final results studies to be sent to the Secretariat by each country, as soon as possible.

Japan and the USSR noted that it would be necessary to consider in detail the frequency application of China, but at first sight it appeared the technical issues could be resolved. CGMS members offered to assist China with its application should it be necessary.

Action 18.43 Japan, China and USSR to submit status reports on satellite frequency allocations to CGMS-XIX.

L.3.1.2 FY-1

EUMETSAT noted that the use of HRPT at 1695.5 MHz on the FY-1 polar orbiting satellite system would severely interfere with the reception of both the MDD transmissions and possibly image dissemination from the Meteosat satellites. China noted that it had the option of using 1704.5 MHz which would not interfere with Meteosat reception stations. A failure in the primary transmitter on the FY-1, however, would mean that the transmissions would have to be made at 1695.5 MHz. China agreed that if this frequency were to be used, it would be possible to switch off the HRPT when the satellite was over the Meteosat field of view.

CGMS stressed that the Meteosat MDD and image dissemination services were essential and that there should not be any interference from other satellite transmissions. China agreed that it would take the necessary steps to ensure that the transmissions from FY-1 satellites did not interfere with the services of other satellite operators.

L.3.2 Prior co-ordination on frequency matters

During its discussion on the possible interference in the operation of DCP and secondary user stations, the CGMS noted that there needed to be a closer co-ordination at the planning stage to avoid potential problems. It believed that it was especially important to arrive at acceptable technical agreements on new or enhanced programmes before the applications were submitted to the telecommunications authorities for approval.

M. MISCELLANEOUS

M.1 International Space Year (ISY)

EUMETSAT introduced Dr. B. Pfeiffer, Head, ISY and Space Awareness Office, ESTEC, who made a presentation on the objectives of the International Space Year 1992. A summary of the large amount of international collaboration was described. CGMS noted that Dr. Pfeiffer would write a letter to the WMO Secretary-General, requesting WMO support for ISY in the areas of education and training.

M.2 Directory of Meteorological Satellite Applications

EUMETSAT informed the meeting that it was intending to produce a Directory of Meteorological Satellite Applications. WP-2 described the format of such a document. EUMETSAT suggested that CGMS members might wish to consider the possibility of jointly producing a similar publication. In addition, CGMS members might wish to consider the creation of a simplistic guide to satellite "Missions and Services". The primary objective of both these publications being the provision of readily accessible information to scientists and decision makers.

CGMS members unanimously agreed that it was very difficult to request adequate funding for future satellite systems and considered that this type of documentation could assist negotiations with National Funding Authorities.

CGMS noted that the first edition of the Applications Directory would comprise mainly European contributions (some 300 topics had been identified to date), hence the production of a second edition with global contributions should be strongly encouraged, and agreed that the activity would be discussed further at CGMS XIX.

Action: 18.44 EUMETSAT to provide CGMS members with copies of the Directory of Meteorological Satellite Applications.

EUMETSAT informed the meeting that a EUMETSAT Missions and Services Guide has been completed and would be distributed in a few weeks.

Action 18.45 EUMETSAT to distribute the EUMETSAT Missions and Services Guide to CGMS members.

CGMS commented that if it were possible to produce CGMS versions of these documents, it could also be regarded as a useful contribution to education and training activities associated with the International Space Year.

WMO informed CGMS that included in the activities of the Third WMO Long-Term Plan, covering the period 1992-1995, was the development of a worldwide satellite applications directory. The purpose of this document was to make WMO Members more aware of the benefits of satellites and their products.

USA proposed that the CGMS document be co-produced with the WMO and suggested that it might also be able to support such a project.

CGMS members agreed to submit proposals for topics to be included in the CGMS Directory of Meteorological Satellite Applications.

Action 18.46 CGMS members to submit proposals for topics to be included in the CGMS Directory of Meteorological Satellite Applications, in time for further discussions of this activity at CGMS XIX.

The USSR informed the meeting that as part of its co-operative programmes relating to ISY, it would like to offer the possibility for joint experiments and flight opportunities for instruments under development on board Russian satellites.

CGMS Members expressed their appreciation of the very generous offer made by the USSR and agreed that the consideration of possibilities for co-operative programmes and flight opportunity instruments should be given a high priority. CGMS noted that an early response would be needed if a flight opportunity in the 1992 1993 time frame were to be taken up.

M.3 Search and Rescue

Japan reported (WP-19) on its plans to install an experimental Search and Rescue (S&R) package on GMS-5, currently scheduled for launch in 1994. This project would begin soon. Japan noted the possibility of interference between the downlink frequency (1698.35 MHz) of its S&R experiment and the downlink frequency of NOAA HRPT, and stated that the experiment schedule would be well coordinated so as not to cause interference.

The USA reported, in WP-20, on the status of its geostationary satellite S&R programme which is to become operational from GOES-I. The CGMS noted that 19 nations, including most CGMS members, are participating in or have declared their intention to participate in the COSPAS-SARSAT programme.

The USSR informed the meeting that its first two GOMS satellites would not carry S&R packages, but a possible expansion of the GOMS-3 payload may allow the development of a geostationary S&R instrument. The USSR also indicated that, although COSPAS/SARSAT packages were currently flown on navigational satellites, in the future they may be flown on RESOURCE environmental satellites.

EUMETSAT regretted that, because of payload limitations, no S&R package could be flown on the current series of Meteosat Operational satellites, however, S&R may become a mission requirement for Meteosat Second Generation satellites.

CGMS agreed that there was now considerable interest in flying S&R packages on future meteorological satellites and that the subject should become a regular Agenda item.

Action 18.47 CGMS Secretariat to add Search and Rescue to the agenda of future CGMS meetings.

M.4 Anomalies from Solar Events

USA-WP-21 described the continuing NOAA programme to consolidate information on satellite anomalies into a PC data base. The USA noted that the charts shown in WP-21 were valid up to early October, but did not include data from the major solar event which commenced on 19 October 1989. Members were asked to forward information relating to this (and other) events to NOAA as soon as possible.

Action 18.48 Satellite Operators to forward information on solar (and other) events to the NOAA National Geophysical data centre as soon as practical.

The USA distributed to each CGMS delegation a floppy disk containing the Satellite Anomaly Monitoring (SAM) programme data base.

CGMS Members were encouraged to utilize this programme and data base for tracking anomalies. Each member could then consider supplying updates to the NOAA data base on a floppy disk.

Action 18.49 The USA to bring an updated SAM data base to CGMS-XIX.

M.5 Environmental Data Collection via Fishing Vessels

USA-WP-23 noted a potential opportunity for collecting environmental data from ocean areas where in situ data is currently very sparse. Certain fishing vessels from South Korea, Japan and Taiwan operating in the North Pacific would carry DCP transmitters which could be used to relay environmental data. The USA informed CGMS that the ARGOS and GOES DCS were the most likely system to be utilized. The USA requested that if GOES DCS were used, that the CGMS consider allocating an IDCS channel so that both GMS and GOES satellites could be utilized, thus expanding the area of coverage.

Japan informed the USA that it had some difficulties to support this programme. The USA noted this concern and proposed to use a GOES domestic DCP channel to support this project.

EUMETSAT enquired if this environmental data would be distributed. The USA informed CGMS that standard US policy would apply and any environmental data collected would be available to any one, including distribution on GTS.

M.6 WMO Satellite Activities Exhibition

The chairman informed the Group about plans of the WMO to develop an exhibition for satellite receiving and display stations which might be donated by Members for short durations and which would be updated on a periodic basis. The purpose of such an exhibition would be to demonstrate to staff, and more importantly, visiting Members, the capabilities of existing workstations and the diversity of satellite data applications. CGMS noted this initiative of the WMO with interest and agreed to support such an endeavour.

Action 18.50 WMO Secretariat to develop a plan for a rotating exhibit of satellite receiving and display stations and to submit it to CGMS for comment.

N. COMMENTS BY THE SENIOR OFFICIALS

N.1 Draft Final Report

The CGMS Senior Officials (Heads of Delegations) reviewed a draft of the Final Report of the meeting. They expressed their appreciation of the efforts made by the Drafting Committee and the WMO Secretariat to produce a relatively voluminous report during the course of the meeting. Having identified some text modifications and error corrections, the Senior Officials approved the draft report. The CGMS Secretariat agreed to incorporate all the proposed modifications into a revised draft which would be distributed to Members within a few weeks for final approval, adding that the Final Report would be published early in 1990.

N.2 Membership of the People's Republic of China

Mr Morgan, noting the considerable level of activity by the People's Republic of China (PRC) relating to the development of future meteorological satellite programmes, proposed to the Senior Officials that the PRC become a full Member of the CGMS.

The meeting unanimously approved full CGMS membership for the People's Republic of China.

In response the PRC thanked the Members for their kind consideration and informed the meeting that the FY-2 satellite programme was now confirmed and funding had been authorised. The PRC also thanked Japan and the USA for the use of data provided by the GMS and GOES satellite systems and for the interchange of technical information, so necessary when embarking upon new satellite programmes. The PRC hoped that there would be further FY-1 and FY-2 satellites, and that they would be able to share the benefits provided by these satellites with neighbours and Members of CGMS, and make a significant contribution to the GOS.

N.3 Agenda

The Senior Officials, noting the growing number of Agenda items of current CGMS meetings, suggested that the idea of parallel working group sessions might be considered once again. These groups would be set up to address items requiring detailed discussions such as frequency coordination or meteorological products. Reports from these working groups would be discussed in plenary session. Noting the possiblity for the setting up specialised working groups and the need to identify specialists to participate in the groups, the Senior Officials recommended that, if possible, the Secretariat should make an earlier distribution of the Agenda.

Action 18.51 The Secretariat to make an earlier distribution of the Agenda for CGMS XIX and to identify Working Groups for items requiring significant or detailed discussions.

N.4 CGMS Logo

CGMS Members agreed that proposals for a revised CGMS logo, reflecting the Group's interest in the coordination of both polar and geostationary meteorological satellite systems, should be submitted to the CGMS Secretariat for consideration at CGMS XIX.

N.5 Closure

The Chairman thanked all Members for their very active participation in the meeting, demonstrating an even greater willingness by all parties for increased cooperation and a desire for fuller coordination of satellite systems. The extent of this active participation being the generation of nearly twice the usual number of Action items !

O. DATE AND PLACE OF NEXT MEETING

The CGMS was pleased to accept the offer made by the USSR to host CGMS-XIX in Tashkent from 10 - 16 December 1990.

P. SUMMARY LIST OF ACTIONS FROM CGMS XVIII

Action 18.1 All CGMS Members to review the proposal to extend the responsibilities of CGMS and transmit any objections to the Secretariat within the next three months. If no objections are forthcoming by 1 April 1990 it will be assumed that the proposal should be implemented.

Action 18.2 EUMETSAT to inform CGMS on the altitude of ejection of METEOSAT-2 from the geostationary orbit.

Action 18.3 USSR to provide Meteor-3 temperature sounding data over the GTS as soon as practical.

Action 18.4 WMO to continue its efforts to acquire INSAT image data tapes.

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

Action 18.6 EUMETSAT to consult with the WMO on the procedures for the inclusion of the MDD in Phase II of the OWSE-AF.

Action 18.7 EUMETSAT to monitor the relay of messages of Syowa to Japan Meteorological Agency.

Action 18.8 CGMS members to provide, on a quarterly basis, listings of IDCS channel assignments to the Secretariat.

Action 18.9 The Secretariat to co-ordinate inputs made by members on IDCS channel assignments and provide consolidated listings to members on a quarterly basis.

Action 18.10 The CGMS Secretariat to send all available information on the IDCS to the People's Republic of China and USSR.

Action 18.11 People's Republic of China and USSR to inform the Secretariat when IDCS channels will be implemented.

Action 18.12 USA to initiate the action by a letter to the Secretary-General including a rationale why profilers could be classified as radio location systems.

Action 18.13 WMO to notify all Members accordingly.

Action 18.14 The Secretariat to include the information in the consolidated IDCS assignment reports and to consider the use of ASCII data formats to allow exchange of information between CGMS members on diskette.

Action 18.15 The WMO to provide the CGMS Secretariat with the results of the ASAP end-to-end test and indicate what action, if any, the CGMS should consider to improve the availability of ASAP data.

Action 18.16 The CGMS Secretariat to work out an implementation programme with the ACC and the WMO Secretariat for allocating additional time slots to the ASAP.

Action 18.17 Satellite operators to work with the CGMS Secretariat (1) to open the necessary channel, (I10 proposed), (2) to monitor the channel to be certain that it would be usable and (3) to agree on time slot and channel assignments for ships, including ASAP.

Action 18.18 The WMO and EUMETSAT to arrange ASDAR test transmissions through the Meteosat satellite system.

Action 18.19 The WMO to complete the procedures for the three month flight trial and to inform the CGMS members.

Action 18.20 The WMO to inform the CGMS Secretariat when the first ASDAR systems will be reporting in time for the ground software to be activated.

Action 18.21 Members to inform CGMS Secretariat by 1 April 1990 if this format is acceptable. Failure to notify will constitute acceptance.

Action 18.22 CGMS Members to provide details of the expected date of implementation and the information contained in each field at CGMS XIX.

Action 18.23 EUMETSAT to report on the progress made with the development of a standard for digital WEFAX to the next meeting of CGMS.

Action 18.24 Japan to provide details on the estimation of ocean surface winds in a typhoon area from GMS images.

Action 18.25 Japan to determine if typhoon CMV information can be relayed over the GTS.

Action 18.26 USA to distribute missing wind statistics information to all members of CGMS.

Action 18.27 CGMS members to include Type 2 data on a monthly basis in quarterly reports.

Action 18.28 USA to provide CGMS with more details of its new wind extraction method.

Action 18.29 EUMETSAT to provide members of CGMS with the COSPAR meeting Announcement.

Action 18.30 CGMS Secretariat to provide information on satellite products to the relevant WMO designated lead centre, on a regular basis.

Action 18.31 EUMETSAT to arrange that the setting up of a CGMS sponsored International Winds Retrieval Group be an agenda item of the COSPAR Winds Workshop, and to provide draft terms of reference for the group.

Action 18.32 The USA to provide information describing VAS products to CGMS-XIX.

Action 18.33 CGMS members to ascertain if there is a general requirement for these new products.

Action 18.34 USA to inform CGMS on the planning of the new archive storage system for its future GOES satellites at CGMS XIX.

Action 18.35 EUMETSAT to provide CGMS members with the references of CEPT documents referring to the protection of the 2 GHz frequency band.

Action 18.36 WMO to prepare an information paper for submission to WARC 92 on the protection of the 2 GHz frequency band.

Action 18.37 CGMS members to raise the issue of the protection of the 2 GHz frequency band with national PTT representatives.

Action 18.38 CGMS members to ensure that the letter prepared by the Secretary-General of the WMO on the subject of the allocation of frequency to data collection services of meteorological satellites is brought to the attention of their national PTT authorities, representatives and frequency managers.

Action 18.39 Japan to study the feasibility of developing an EBB.

Action 18.40 People's Republic of China to provide the Secretariat with details on telecommunication networks in its country.

Action 18.41 USA and EUMETSAT to submit a standardized subset of bulletin boards, which could be supported by all CGMS Members operating an EBB to the secretariat by 1 February 1990.

Action 18.42 EUMETSAT to provide USA with details of its stand-alone PC based EBB system.

Action 18.43 Japan, China and USSR to submit status reports on satellite frequency allocations to CGMS-XIX.

Action 18.44 EUMETSAT to provide CGMS members with copies of the Directory of Meteorological Satellite Applications.

Action 18.45 EUMETSAT to distribute the EUMETSAT Missions and Services Guide to CGMS members.

Action 18.46 CGMS members to submit proposals for topics to be included in the CGMS Directory of Meteorological Satellite Applications, in time for further discussions of this activity at CGMS XIX.

Action 18.47 CGMS Secretariat to add Search and Rescue to the agenda of future CGMS meetings.

Action 18.48 Satellite Operators to forward information on solar (and other) events to the NOAA National Geophysical data centre as soon as practical.

Action 18.49 The USA to bring an updated SAM data base to CGMS-XIX.

Action 18.50 WMO Secretariat to develop a plan for a rotating exhibit of satellite receiving and display stations and to submit it to CGMS for comment.

Action 18.51 The Secretariat to make an earlier distribution of the Agenda for CGMS XIX and to identify Working Groups for items requiring significant or detailed discussions.

Q. LIST OF PARTICIPANTS AT CGMS XVIII

CBS	Dr T Mohr
ESA	Mr B Mason
EUMETSAT	Mr J Morgan Mr G Bridge Mr R Wolf
JAPAN	Mr T Noumi Mr M Togashi
PEOPLES REPUBLIC OF CHINA	Mr Xu Jian Ming Ms Sun Huaisu Mr Xu Xi Mr Huang Hanwen
USA	Mr L Heacock Mr C Staton Mr C Cripps
USSR	Mr V Kharitonov
WMO	Mr S Mildner Mr D Hinsman Mr J Giraytys

ANNEXES

ANNEXES TO THE FINAL REPORT OF CGMS XVIII

List of Abbreviations and Acronyms

LIST OF ABBREVIATIONS AND ACRONYMS

ACC	ASAP Coordinating Committee
AM/FM	Amplitude/Frequency Modulation
AMRIR	Advanced Medium Resolution Imaging Radiometer
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
ASPP	Advanced Satellite Products Project (USA)
AVHRR	Advanced Very High Resolution Radiometer
BUAN	Baseline Upper Air Network
BUFR	Binary Universal Form for data Representation
CAA	Civil Aviation Authority (UK)
CAC	Climate Analysis Centre (USA)
CAD	Committee on ASDAR Design
CBS	Commission for Basic Systems
CDA	Command and Data Acquisition Station
CEOS	Committee on Earth Observations Satellites
CEPT	Conference European des Postes et Telecommunications
CGMS	Committee for coordination of Geostationary Meteorological Satellites
CMS	Centre de Meteorologie Spatiale (Lannion)
CMV	Cloud Motion Vector
COSPAR	Committee on Space Research
DAPS	DCS Automated Processing System (USA)
DCP	Data Collection Platform
DCPR	Data Collection Platform report
DCS	Data Collection System
DPC	Data Processing Centre
DRS	DCP Retransmission System (Meteosat)
DRT	Data Relay Transponder (INSAT)
DWS	Disaster Warning System (India)
EBB	Electronic Bulletin Board
EC	Executive Council (WMO)
ESA	European Space Agency
ECMWF	European Centre for Medium range Weather forecasts
ELV	Expendable Launch Vehicle
ERBE	Earth Radiation Budget Experiment
ERS-1	European Remote Sensing Satellite (first)
ESOC	European Space Operations Centre
ESTEC	European Space Technology Centre
EUMETSAT	European Meteorological Satellite Organisation
EVIRI	Enhanced VIS and IR imager (MSG)
FAA	Federal Aviation Authority (USA)
FAX	Facsimile
FGGE	First GARP Global experiment
FY-1	Polar Orbiting Meteorological Satellite (PRC)
FY-2	Future Geostationary Meteorological Satellite (PRC)
GMR	GOES-Meteosat Relay
GMS	Geostationary Meteorological Satellite (Japan)
GOES	Geostationary Operational Environmental Satellite (USA)

Annex I

GOMS	Geostationary Operational Met. Satellite (USSR)
GOS	Global Observing System
GPCP	Global Precipitation Climatology Project
GTS	Global Telecommunications System
GVAR	GOES Variable (data format) (USA)
HRPT	High Resolution Picture Transmission
HRVIS	High Resolution VIS imager (MSG)
HSRS	High Spectral Resolution Sounder (MSG)
INSAT	Indian geostationary satellite
IR	Infrared
IRS	Indian Remote Sensing Satellite
ISCCP	International Satellite Cloud Climatology project
ISY	International Space Year
ITU	International Telecommunications Union
JMA	Japanese Meteorological Agency
LR	Low Resolution
MCP	Meteorological Communications Package
MDD	Meteorological Data Distribution (Meteosat)
METEOSAT	European geostationary meteorological satellite
MOP	Meteosat Operational Programme
MOS	Marine Observation Satellite of Japan
MSC	Meteorological Satellite Centre (Japan)
MSG	Meteosat Second Generation
MSU	Microwave Sounding Unit
NASDA	Japanese National Space Agency
NESDIS	National Environmental Satellite Data and Information Service (USA)
NGDC	National Geophysical Data Centre (USA)
NHC	National Hurricane Centre (USA)
NMC	National Meteorological Centre
NOAA	National Oceanographic and Atmospheric Administration
NSSFC	National Severe Storms Forecasting Centre (USA)
NWP	Numerical Weather Prediction
NWS	National weather service (USA)
OCAP	Operational Committee of ASDAR Participants
OD	Optical Disc storage
OLR	Outgoing Longwave Radiation
OWSE	Operational WWW Systems Evaluation
PC	Personal Computer
PRC	Peoples Republic of China
PCM/PSK	Pulse Code Modulation/Phase Shift Keying
PTT	National Post and Telecommunications Authority
RMS	Root Mean Square
S&R	Search and Rescue mission
SAM	Satellite Anomaly Monitoring
SAREP	Synoptic interpretation of cloud data obtained by a met satellite, WMO code form FM 85-VI
SARSAT	Search And Rescue, Satellite supported facility
SCIC	Satellite Cloud Information Chart (Japan)
SDSD	Satellite Data Services Division (USA)
SDUC	Secondary Data Utilisation Centre
SDUS	Secondary Data User Station (Meteosat)
SEAS	Shipboard Environmental (data) Acquisition System
SEM	Space Environment Monitor
SFCG	Space Frequency Coordination Group
SI	Satellite derived Index of precipitation (Japan)
SLR	Sideways Looking Radar

SOCC	Satellite Operations Control Centre
S-VISSR	Stretched VISSR (see below)
SST	Sea Surface Temperature
SSU	Stratospheric Sounding Unit
TOGA	Tropical Ocean and Global Atmospheric Programme (WMO)
TTC	Telecommand and Telemetry Centre (Japan)
TT&C	Tracking, Telemetry and Command station
UTC	Universal Time Coordinated
VAS	VISSR Atmospheric Sounder
VDUC	VAS Data Utilisation Centre
VHRR	Very high resolution radiometer
VIS	Visible channel
VISSR	Visible and Infra-red Spin Scan Radiometer
WCRP	World Climate Research Programme
WEFAX	Weather facsimile
WGD	Working Group on Data (CEOS)
WMO	World Meteorological Organization
WP	Working Paper
WV	Water Vapour
WWW	World Weather Watch

Annex II

Recommendations from the WMO EC Panel of Satellite Experts

Summary Recommendations from the WMO

EC Panel of Experts on Satellites

The Panel :

- stressed the urgency for implementing standard and routine dissemination of satellite data from INSAT
- encouraged EUMETSAT to provide a polar orbiting satellite system within the Global Observing System (GOS)
- noted the following deficiencies of the present space based portion of the GOS :

  * inadequate vertical resolution of sounders
  * inadequate horizontal coverage in the Indian Ocean
  * lack of assurance that there will be two polar orbiting satellites from the 1997/1998 time frame
  * lack of clarity on which countries or organizations will be satellite operators with particular reference to Europe
  * lack of continuity of sensors for polar orbiting satellites, especially during 1997 - 2001 when different imagers/sounders may be flown on morning and afternoon satellites

In addition, the Panel recognized:

- the need to improve the use of satellite applications by centres other than major centres
- the need for an approved international processing programme for sounding retrievals of ATOVS
- the need to define daily frequency and temporal spacing of coverage from polar orbit
- the need to form an international working group similar to the TOVS working group, dedicated to wind retrievals
- a priority list for new sensor development as follows:

Priority List for New Experimental Development (continued)

* 3 dimensional wind measurements (Doppler Wind Lidar)
* precipitation over ocean (active/passive microwave sounding)
* atmospheric discontinuities and cloud top height (backscatter Lidar)
* surface pressure (dial Lidar, high resolution spectroscopy)

- a list of instruments to supplement the present GOS, but using proven technology, e.g. :

  * Improved IR sounder
  * Microwave sounder
  * Passive microwave imager
  * Earth radiation budget instrument, scanning with a narrow field of view
  * Improved accuracy SST sensor - existing instruments fail to meet 0.25 degrees absolute accuracy
  * Altimeter
  * Ocean Colour monitor
  * Chemistry sensor (total ozone)

- more effective contingency planning
- a data base for meteorological satellite ground base receiving equipment
- a re-definition of the GOS to include all WMO programmes

  (CBS to draft detailed recommendations for a new revised GOS)
- CBS to organise an OWSE-SAT for minimum performance characteristics of work stations
- a new data exchange policy for free and open exchange
- the EC Panel to meet every 2 years.

Annex III

Working Papers Submitted to CGMS XVIII

WORKING PAPERS SUBMITTED TO CGMS XVIII

(Agenda Item in brackets)

EUMETSAT

EUM-WP-1	Review of Action Items (A.5)
EUM-WP-2	Review of Consolidated Report (A.6)
EUM-WP-3	Report on Meteosat Operational Programme (B.1)
EUM-WP-4	T-MOP (C.1.1)
EUM-WP-5	Meteosat Second Generation - status (C.1.1)
EUM-WP-6	EUMETSAT Polar System - status (C.2.1)
EUM-WP-7	Use of Meteosat-3 for Atlantic Data Coverage (D.1)
EUM-WP-8	INSAT relay - status report (D.1)
EUM-WP-9	GOES relay - upgrade (D.1)
EUM-WP-10	Review of IDCS Users Guide (F.4)
EUM-WP-11	Meteosat HR and LR (WEFAX) Dissemination (G.1.1)
EUM-WP-12	Atlantic Data Coverage - Dissemination schedule (D.1)
EUM-WP-13	Possible use of CLS ARGOS for DCP ((G.1.3)
EUM-WP-14	Further developments with digital WEFAX (G.1.4)
EUM-WP-15	Meteorological Data Distribution (G.3)
EUM-WP-16	Report of joint EUMETSAT/ECMWF Workshop (J)
EUM-WP-17	Protection of the 2 GHz band (L.1)
EUM-WP-18	Report of SFCG meeting - Kiruna (L.1)
EUM-WP-19	Development of an Electronic Bulletin Board (L.2)
EUM-WP-20	International Satellite Year (M.1)
EUM-WP-21	Directory of Satellite Applications (M.2)
EUM-WP-22	Use of ERS-1 Data in Europe (G.3)
EUM-WP-23	Joint Activities to improve CMV extraction methods (I.1)
EUM-WP-24	Extension of the Responsibilities of the CGMS (A.7)

JAPAN

Japan-WP-1	Comparison of transmission frequencies between Chinese FY-2 and GMS-3/GMS-4 (A.5)
Japan-WP-2	Corrigendum to Consolidated Report (A.6)
Japan-WP-3	Status of GMS-3 VISSR Observations (B.3)
Japan-WP-4	Geostationary Meteorological Satellites Status (B.3)
Japan-WP-5	Geostationary Meteorological Satellite-5 (C.1.3)
Japan-WP-6	Earth Observation Programme in Japan (C.2.3)
Japan-WP-7	Status and Problems of IDCS (F.1)
Japan-WP-8	Ships, including ASAP (F.2)
Japan-WP-9	ASDAR (F.3)
Japan-WP-10	Dissemination of Stretched-VISSR and WEFAX (G.1)
Japan-WP-11	The operation of SAREP (G.2)
Japan-WP-12	DCP Data (G.3)
Japan-WP-13	Status Report on GMS Wind Derivation (I.1)
Japan-WP-14	Low Level Cloud Wind Derivation in a Typhoon Area from GMS Short Time Interval Images (I.1)
Japan-WP-15	Satellite Index of Precipitation Intensity (I.3)
Japan-WP-16	Use of Cloud Amount Anomaly Data to Assist Long Range Forecasting (I.4)
Japan-WP-17	Parameterisation of Regions of Deep Convection (J)
Japan-WP-18	Withdrawn
Japan-WP-19	S&R Experiment on GMS-5 (M.3)

Peoples Republic of China (PRC)

PRC-WP-1	Polar Orbiting Meteorological Satellite FY-1 HRPT Spectrum (A.5)
PRC-WP-2	First Flight Status of experimental and trial polar orbiting satellite FY-1 (B.4)
PRC-WP-3	Plan of China Geostationary Meteorological Satellite System (C.1.4)

USA

USA-WP-1	Review of Action Items from CGMS XVII (A.5)
USA-WP-2	Status of US Satellite Systems (B.5)
USA-WP-3	Future satellite systems (GOES) (C.1.5)
USA-WP-4	Future satellite systems (KLM) (C.2.5)
USA-WP-5	Satellite Continuity (D.2)
USA-WP-6	Weatherwatch International (L.2)
USA-WP-7	Status of IDCS (F.1)
USA-WP-8	ASDAR update (F.3)
USA-WP-9	WEFAX Schedules and Common Header (G.1.2)
USA-WP-10	DCP data/Update on DAPS (G.1.3)
USA-WP-11	Digital WEFAX (G.1.4)
USA-WP-12	Comparison of Satellite Winds (I.1)
USA-WP-13	Increased domain for extraction (I.1)
USA-WP-14	Quality of satellite winds NESDIS (I.1)
USA-WP-15	Plans for Winds Quality Control (I.1)
USA-WP-16	Precipitation and Cloud Cover (I.3)
USA-WP-17	VAS Products (I.3)

USA-WP-18	New Products (GOES +) (I.4)
USA-WP-19	New Products (NOAA KLM) (J)
USA-WP-20	GOES Search and Rescue Program (M.3)
USA-WP-21	Satellite Anomalies (M.4)
USA-WP-22	Wind Profiler Interference (F.1.2)
USA-WP-23	Environmental Data Collection via Fishing Vessels (M.5)

WMO

WMO-WP-1	Review of Previous Actions (A.5)
WMO-WP-2	Review of the Consolidated Report (A.6)
WMO-WP-3	Ships, Including the Automated Ship-board Aerological Programme (ASAP) (F.2)
WMO-WP-4	Implementation of the operational ASDAR Programme (F.3)
WMO-WP-5	Status of the Planning for the OWSE-Africa (E.1)
WMO-WP-6	Requirements for New ASAP Time Slots to be Allocated on an Additional IDCS Channel (F.2)
WMO-WP-7	Allocation of Frequencies to the DCS (L.1)

Proposal to Extend the Responsibilities of CGMS

CGMS-XVIII EUM-WP-21
Prepared by EUMETSAT
Agenda item: M

EXTENSION OF RESPONSIBILITIES OF THE CGMS

Summary and Purpose of Document

It is proposed to extend the responsibilities of CGMS to include further discussion of planning, operation and use of polar meteorological satellites. This could be achieved as an extension of the present informal objectives of CGMS and a change in its name to the "Co-ordination Group for Meteorological Satellites".

Action required

CGMS members are requested to review the proposal and transmit any objections to the Secretariat within the next 3 months. If no objections are received by 1 April 1990 it will be assumed that the proposal should be implemented.

EXTENSION OF RESPONSIBILITIES OF THE CGMS

1. The Co-ordination of Geostationary Meteorological Satellites (CGMS) is an informal group first established in 1972 through a meeting of representatives of the European Space Research Organization, Japan, the United States of America and observers from the World Meteorological Organization (WMO) and the Joint Planning Staff of the Global Atmospheric Research Programme. This first meeting discussed questions of compatibility among geostationary meteorological satellites and identified several areas which were subsequently the subject of successful co-operation and standardisation.

2. CGMS-XVII took place in October 1988, by which time the members included representatives from EUMETSAT, India, Japan, USA, USSR and the WMO. The People's Republic of China also attended with observer status. At this meeting it was realised that for the first time, all of the meteorological satellite operators were present including the USA (operating the NOAA satellite), the USSR (Meteor satellites) and the People's Repulic of China (which had recently launched the experimental FY-1). Taking advantage of this fact, the CGMS agreed to hear informal presentations of the status of polar meteorological satellite systems and agreed to add this item to the agenda of future meetings of the CGMS.

3. The CGMS remains the only body in which all of the meteorological satellite operators can meet and exchange views and experiences. The International Polar Orbiting Meteorological Satellite Group (IPOMS) and similar groups have term of reference concerned with the continuation of the present NOAA satellite systems, but are not concerned with routine operations and do not include the USSR, People's Republic of China or the WMO as members. The presence of WMO representatives (both from the Secretariat and CBS) is an important factor in the success of the CGMS since this ensures contact between the satellite operators and representatives of the user community.

4. The WMO EC Panel of Experts on Satellites met in Geneva on 6-10 November 1989. The Panel noted with concern the lack of guaranteed data continuity in polar orbit and indicated that it would be useful to encourage greater co-operation amongst potential meteorological satellite operators worldwide. They, therefore, recommended that the CGMS terms of reference should be extended to cover polar meteorological satellites, including representatives from actual and potential operators of meteorological satellites. This would not immediately necessitate any changes in CGMS membership.

5. Several of the present CGMS members are in clear support of this recommendation. It is, therefore, proposed that the CGMS should agree to discuss polar meteorological satellites at future meetings. Agenda items could include:

- Status
- Plans
- Operational matters
- Products
- Data formats
- Future standards

5. These topics would not conflict with the programme orientated activities of groups such as IPCMS and would facilitate an extremely useful exchange of views and experiences. This would enable the CGMS to play an important role in continuing and improving the space-based portion of the WMO's Global Observing System, as well as assisting in the more effective utilisation of space-based systems.

6. It is, therefore, recommended that this change of responsibility should take effect from the date of CGMS-XIX. On that occasion the name of CGMS should be changed to Co-ordination Group for Meteorological Satellites. This allows the well known and historically important acronym of the CGMS to be retained.

Annex V

Report on the status of the INSAT Satellite System

REPORT ON THE STATUS OF INSAT SATELLITE SYSTEMS

(Report received by the Secretariat shortly after the meeting)

Paragraph numbering follows that of the Agenda

B.2.1. STATUS OF INSAT-IB

INSAT-IB was launched on 30th August 1983 and declared operational from 15th October, 1983. It has worked satisfactorily for the last 6 years except for a brief loss of earth-lock in August, 1984 resulting in temporary disruption of services for about 36 hours. The satellite has been maintained in its designated orbital position (74 degrees East ± 0.1 degree) and it has worked satisfactorily.

On 17 Oct 1989 and 20 Oct 1989, there were two instances of loss of earth-lock. Immediately after these events the spacecraft was put into safe sun-acquisition mode and subsequently manoeuvres to re-acquire earth lock and to revert the spacecraft to the normal operational mode were carried out successfully. According to present estimates it will be possible to keep the satellite within 0.2 degree inclination until 15 Dec 1989.

B.2.2 STATUS OF INSAT-IC

INSAT-IC, the in orbit spare of INSAT-IB, was launched by ARIANE-3 launch vehicle into a geostationary orbit on 22nd July, 1988. Due to a massive short in one of the two power buses on board the spacecraft, only about 50% of the total required power is available to operate various payloads of the satellite. It is possible to operate both meteorological payloads, i.e. the Very High Resolution Radiometer (VHRR) and the Data Relay Transponder (DRT). In orbit check-out has shown that the performance of various payloads is satisfactory.

Following the recent two occasions of loss of earth-lock with INSAT-IB, INSAT-IC has been used as the operational spacecraft for VHRR and DCP with effect from 18 Oct 1989.

B.2.3. OPERATIONAL USE OF INSAT

INSAT-IC meteorological data are being processed on an operational basis at the Meteorological Data Utilisation Centre (MDUC) located in the India Meteorological Department, New Delhi. The VHRR data are processed at the MDUC to provide the following products:

a) Earth Cloud Cover Images in the Visible and Infrared Bands

11 full earth disc scans are routinely obtained on a daily basis. Additional ingests are also commanded during important weather situations. Based on the analysis of these pictures regular bulletins are sent to the users.

b) Cloud Motion Vectors

Cloud Motion Vectors (CMV) in the upper levels of the atmosphere are being derived at 06 UTC using cloud pictures taken in the VIS band at successive half hourly intervals. Winds are being derived over the Arabian Sea, Bay of Bengal and Indian Ocean areas and are transmitted over the National Meteorological Telecommunication network for utilisation within India and over the GTS for international utilisation.

c) Sea Surface Temperatures

Data obtained from the VHRR are being used for the derivation of Sea Surface Temperature (SST) on an experimental basis in the Bay of Bengal, Arabian Sea and part of the Indian Ocean.

d) Estimation of Precipitation and Outgoing Longwave Radiation

Estimation of Quantitative Precipitation Index is made using 3 hourly INSAT-IB data. Such precipitation estimates are averaged over large areas (2.5 degrees square Lat./Long.) over a week or a month. Similarly Outgoing Longwave Radiation (OLR) weekly and monthly derivations are being made over 2.5 degrees (Lat./Long.) square areas.

B.2.4. DATA DISSEMINATION SERVICES

Cloud image data obtained from INSAT-IB are transmitted through dedicated communication links every three hours, in analogue facsimile mode, to 20 Secondary Data Utilisation Centres (SDUCs) located at various important forecasting offices in the country.

INSAT-IB also provides the following two communication services for meteorological purposes:

a) The Data Relay Transponder (DRT) on board INSAT-1 satellites is used for the collection of meteorological and hydrological data from 100 land based Data Collection Platforms (DCPs).

b) A scheme for the direct dissemination of cyclone warnings through INSAT to coastal areas likely to be affected, has been operational since January 1986. This scheme, called INSAT Disaster Warning System (DWS), has been initially implemented on an experimental basis in some selected coastal areas of India. The performance of this scheme has been found to be satisfactory on an operational basis when two cyclonic storms affected the area during 1987. Under this scheme 100 DWS receivers were deployed in the field for reception of cyclone warnings through INSAT.

   In this scheme cyclone messages originating from the Area Cyclone Warning Centre, Madras, are transmitted to INSAT from an Earth Station near Madras. The S-band transponder of INSAT receives and relays back these signals over the Indian Territory for direct reception by DWS receivers. The signals selectively address specific DWS receivers.

C.1.2 FUTURE INSAT SATELLITE SYSTEMS

a) <u>INSAT I System</u>

   INSAT-ID, the last satellite in the present INSAT-I series of satellites, is expected to be launched around the middle of 1990. The launch had to be postponed from July 1989 following an accident at the launch pad resulting in damage to the satellite. Currently re-work on the satellite is in progress in the USA. INSAT-ID will be first placed at 83 degrees East and eventually it will replace the currently operational INSAT-IB satellite at 74 degrees East.

b) <u>INSAT II System</u>

   During the 1990s a new satellite series, INSAT-II, will replace the currently operational INSAT-I satellite series, in a phased manner. The first two satellites of the INSAT-II series are already under fabrication in India. At present an Electrical Thermal Model of the spacecraft if being fabricated and a critical Design Review will be held shortly. The first satellite of the INSAT-II series is expected to be launched in late 1990 or early 1991 using an Ariane launch vehicle. The INSAT-II satellites will also be 3-axis stabilized multi-purpose satellites and their meteorological payloads will comprise:

i) A Very High Resolution Radiometer (VHRR) for imaging the earth's cloud cover in visible and IR channels. The resolution at sub-satellite point will be 2.0 km (visible) and 8 km (IR). The VHRR will be used for imaging the earth's cloud cover over India and adjoining land and sea areas. There will be a capability for full earth scan with 20 degrees (N-S) x 20 degrees (E-W) Scan angle and for Sector scan (20 degrees E-W x 4.5 degrees N-S). Normally VHRR will scan 14 degrees (N-S) x 20 degrees (E-W) field of view for most day-to-day operations.

ii) A 400 MHz Data Relay Transponder (DRT) like INSAT-I, for the collection of meteorological data for remote and inaccessible areas.

iii) A 406 MHz (Uplink) transponder will also be provided on INSAT-II satellites, for the satellite aided Search and Rescue programme.

Annex VI

Characteristics of Meteorological Satellites of the USSR

State-of-the-Art and Prospects for Earth Resources and Hydrometeorological Satellite Systems Development

INTRODUCTION

Space technology is widely applied in people economy of the USSR. One of the most important categories of space technology development is the remote sensing of the Earth from space for weather services, ocean and atmosphere studies. Earth resources exploration, natural environment monitoring purposes.

Continious acquisition of satellite remote sensing data (space information on the Earth) is supported mainly with two types of satellite systems, differing from each other with mode for data transmission to ground stations; operational and non-operational (photographic) satellite systems.

Operational satellite systems transmit remote sensing data down to ground stations via radiochannels in direct broadcast mode or after recording and short-time delay at on-board recorders.

Photographic imaging information on Earth surface is available when entire space imaging program is over and therefore it is used only to study low changing processes and stable formation to create cartographic base, to compose geological charts; to study geological structure; to make soil maps; as well as when constructing transport roads; land-using and a number of other purposes.

Operational satellite systems are designed to analyse vast changing dynamics of natural environmnet. High frequency of observations and short-time delivery of satellite information is needed for hydrometeorological data provision to USSR economy; to detect and monitor natural disasters, typhoons, hurricanes, flashfloods, forest fires; to delineate natural environment zones under pollution for agricultural and forest use applications, great number of other economic purposes and to monitor the state of world oceans.

Operational satellite systems are ordered by USSR Research Center for Earth Resources Exploration (URCERE) under State Committee for Hydrometeorology (SCHM). URCERE in colloboration with other organizations develops separate complexes for operational satellite systems, data processing and applications systems, as well as evaluates prospects for operational space systems and complexes. Receiving, processing hardcoping and distribution to users of information, down transmitted from current operational satellite systems is run by Main Data Receiving and Processing Center (MDRPC) under URCERE and Main Computer Center (MCC) for SCHM (both located at

Moscow) and Regional Computer Centers (RCC) for SCHM at Novosibirsk Khabarovsk, Tashkent (until 1987 september named as RDRPC regional data receiving and processing centers).

This paper describes the state and development prospects for operational satellite systems only.

It should be noted, that currently available separate operational space systems are run and designed as nearest step of evolution to provide hydrometeorological contribution to USSR economy (meteorological systems), land resources exploration (resources systems). The use of different complexes and systems is stipulated by requirements in frequency of data acquisition, space and spectral resolutions, other characteristics of satellite data to be applied in various industries. Moreover physical parameters characterising state of atmosphere, ocean and land targets are also different. Variability ranges of these parameters are rather different as well. Application of different satellite systems and complexes is due to state-of-the art in satellite engineering which does not allow to develop unified system capable of observing land targets, ocean and natural environment simultaneously. It must be noted that even at present time many parameters of world ocean, ice conditions on nothern seas, disasters and other phenomena are determined and evaluated with data from both meteorological satellite systems and also from satellite systems designed for world ocean studies and Earth resources exploration.

I. METEOROLOGICAL SATELLITE SYSTEMS

I.I. Running satellite systems for hydrometeorological data provision to USSR economy

At present the USSR runs a meteorological system called "Meteor-2".

The system is composed of two to three permanently operated near polar orbiters at an average altitude of about 900 km with orbit inclination of 82,5° and of data receiving and processing centers at Moscow, Novosibirsk and Khabarovsk and more than 80 simplified autonomous data receiving stations (SADRS). In 1986 the fourth data receiving and processing center was organized at Tashkent. The onboard sounding payload is composed of three types of TV scanners in visible and IR, eight-channel scanning IR radiometer and radiation sensor. This instrumentation provides twice daily information on distribution of clouds, snow and ice covers, radiative temperatures and on vertical profiles of atmospheric temperatures. The measurements cover 80% USSR territory. List of instruments and their characteristics are given in table 1.

All data from "Meteor-2" satellite after being completely processed at MCC and at other processing centers is transmitted to USSR Hydrometeorological Center (HMC), regional and local forecast centers, and to other users via communication links including meteorological center in socialistic countries.

"Meteor-2" series satellites transmit TV information in direct broadcast mode, due to that cloud, ice, snow cover images and imagery of other types of underground surfaces in the visible range of spectrum over 6 to 7 mln km^2 may be received 2 to 3 times daily at any region of the globe.

Simultaneously with already exploited "Meteor-2" system meteorological satellite "Meteor-3" system is tested. Now main task for these satellites is further improvement of mateorological satellite system including information-measurement instrumentation and tecniques for remote sensing of atmosphere and Earth surface meteorology, various industries and science applications. Successful tests of this orbiters began in 1985 October 24 when "Meteor-3" satellite was launched. These satellites are flown on near-circular orbits at an altitude of about 1200-1250 km. Orbit inclinations are 81° to 83°. Higher altitudes enable to have extended swathwidth for TV on-board systems and provide global coverage of the Earth surface.

Table 2 gives technical characteristics of equipment and instrumentation which will be operated in timely mode.

"Meteor-3" system after being operational and being composed of 2-3 satellites will enable to have global TV images of illuminated side of the Earth and radiation data not less than two times daily; global IR images of illuminated and shadow sides of the Earth not less than four times daily; atmospheric temperature-humidity data, SST data; data on temperatures and heights of top clouds at every broadcast contact as well as to receive data in direct mode at SADRSS. Experimental instrumentation to be flown on these satellites will allow additionally to collect data on total ozone concentration and its vertical distribution and on radiation budget constituents within Earth-atmosphere system.

Satellite meteorological information is widely and successfully used in weather forecasting and also to determine hurricane locations, atmospheric fronts, disasters; to make oceanic ship routes and for aircraft navigation. Satellite TV imagery will enable to assess ice covers on seas and oceans, large lakes, water reservoirs and rivers.

Table 1

Characteristics of sensors flown or "Meteor-2" satellite and output data

Instrument	Spectral band, µm	Swathwidth at an altitude of 900 km	Resolution, km	Output products
1	2	3	4	5
Scanning TV system for direct relay of cloud and underlying background imagery	0,5 - 0,7	2100	2	Individual images photocosition of images from 2-3 passes for receiving station area of up to 2000 km in radius
Scanning TV system with onboard data recorder to yield global coverage imagery	0,5 - 0,7	2400	1	Individual images, global photocharts, photocomposition of images of various regions of the globe (2-3 times daily), photocomposition of arctic and antarctic seas images, obtained under cloud-sparse conditions one time in 5 days

Table 1 (cont.)

1	2	3	4	5
Global coverage Scanning IR radiometer	8 - 12	2600	8	Global photocompositions of Northern, Southern Hemispheres, tropical zones; individual images; digital charts for SST and top cloud heights; tropical hurricane coordinates and date on cloud estimates at regular grid nodes for entire globe
Scanning eight-channel IR radiometer for atmospheric thermal sounding	11,1 - 18,7	1000	32 x 32; angular 2° x 2°	SATEM messages with atmospheric thermal sounding data
Radiative-metric complex	0,15 - 90 MeV			Data on radiation

Table 2

Technical characteristics of instruments on "Meteor-3" meteorological satellite

Instruments	Spectral band, µm	Swathwidth, km	Resolution, km	Operation mode
Scanning TV equipment with on-board data recorder to have global coverage	0,5 - 0,8	3100	0,7 x 1,4	Recording, direct broadcasting
Scanning TV equipment for data transmission to SADRSs	0,5 - 0,8	2600	1 x 2	Direct transmission
Global observation IR radiometer to transmit data to SADRSs	10, - 12,5	3100	3 x 3	Recording, direct transmission
Ten-channel scanning IR radiometer	9,65 - 18,7	22,5°	2°	Recording, direct transmission
Radiation metric complex	0,17 - 600 MeV			Recording, direct transmission

I.2. Prospects for meteorological satellite development.

Experience gained in designing and exploiting "Meteor-2" and " Meteor-3"systems, conducted satellite experiments and applications of space information from "Meteor-Priroda", "Kosmos-1500" and other series satellites have permitted to provide insight into ways to evolve and improve meteorological satellite systems.

To improve meteorological satellite system in 1990's it is envisioned to create a single comprehensive system for hydrometeoro - logical data provision, which will be configurated with geostationary and middle altitude meteorological orbiters, information characteristics of which will be analogous to ones of "Meteor-3" satellites. TV instrumentation on medium-altitude orbiters will be multi - channel-operated and will have higher space resolution. Spectrometric systems will provide more accurate measurements of atmospheric parameters. New visible, UV and IR remote sensing sensors will be used. Satellite measurements will yield more accurate estimates for temperature vertical profiles, integral humidity of atmosphere, total ozone concentration and its vertical distribution, atmospheric pollution with some components, radiation budget, ect. Information from satellites will be of digital form.

At this stage geostationary satellites will carry scanners producing cloud and underlying surface imagery of ground resolution of about 1 - 2 km in the visible (0,4-0,7 µm); and of about 5 - 8 km in the IR (10,5 - 12,5 µm) radiotechnique facilities to collect and retransmit information; and instrumentation for geophysics measurements. The payload will near-continuously observe rapidly changing dynamics of atmospheric phenomena over Earth surface within moderate and low latitudes; quickly locate natural disasters; determine wind speed and direction at several levels; SST and other parameters of atmosphere and underlying surface. Radiotechnique payload of geostationary satellite will enable to acquire hydrometeorological and geliophysical data from data collection platforms (DCPs); data exchange among ground centers; medium orbit satellite data retransmission and final product delivery to users. Ground data receiving and processing centers will be also significantly modified. They will be equiped with the state-of-the-art computers and interactive processing and analysis methods will be applied.

The contribution of hydrometeorological data to the USSR economy will be also supported with data from satellites similar to "Kosmos-1500" oceanographic orbiters. Optical and radio scanners to be flown on these satellites will provide all-weather, day and night measurements of sea surface parameters, Arctic and Antarctic ice cover as well as ice on rivers, water reservoirs; ice drift direction; clouds and precipitation.

The main trend in meteorological satellite system development is the provision of more timely measurements, higher space resolution (both horizontal and vertical); broadening of the height range of measurements that will increase the number of atmospheric and underlying surface parameters to be assessed and will support development of data processing, analysis and presentation techniques.

Main disadvantage of geostationary satellites is that they are not capable to observe polar and near-polar region. Preliminary analysis have shown that for timely acquisition of hydrometeorological data over USSR territory, situated mainly within moderate and high latitudes it would be most effective to launch satellites on inclined twenty-four hours orbits. Unlike geostationary satellites these orbiters cover regions not limited with moderate latitudes. Depending on orbit inclination a satellite can observe also high latitude regions including near-polar and polar zones. Thus future satellite system for hydrometeorological data provision should be made up of following subsystems:

- geostationary and near-polar twenty-four hours orbit satellites to collect global optical and IR data on the cloud cover and its distribution; wind vectors at several levels; vertical temperature profiles; SST; radiation budget components; geliophysical parameters and radiative situation at corresponding levels as well as to run collection and retransmission of data from DCPs, other satellite systems and aircrafts to receiving and processing centers; plus data transmission from main to territorial centers and data exchange among regional ones;

- subsystem assembled with medium-altitude near-polar orbiters. In comparison with the currently available subsystem the future one will enable gathering timely data on cloud water content, cloud phase composition, precipitation zones and amount, aerosol and minor gas constituent parameters; atmospheric optical characteristics and others.

It should be noted that many aspects in creating the future single comprehensive satellite system, specific payload components and their technical characteristics need to be further analysed and require theoretical and engineering study. To solve these problems adhoc satellite experiments will be carried out.

II. SATELLITE PAYLOAD AND SYSTEMS TO EXPLORE NATURAL RESOURCES OF THE EARTH AND WORLD OCEAN

II.1. Available satellite systems and complexes

The first experimental satellite to acquire timely information on Earth resources was launched in 1974 july 9. This series satellites later became known as "Meteor-Priroda" ones. From this moment multichannel information, transmitted from satellites, was recorded and timely processed at URCERE and other centers under SCHM and then was delivered to all organizations concerned. Further development of experimental "Meteor-Proroda" system may be presented with Earth resources ad hoc satellite of "Kosmos 1689" series, which will provide regular space information up to early 1990's.

First two "Meteor-Priroda" satellites were on orbits of about 900 km in altitude and of 82° inclination, but succesors - on sunsynchronous ones of about 650 km altitude and of 98° inclination. Active life-time of these orbiters is 1 - 2 years. Main instrument for multizonal imaging over Earth surface targets up to 1980 was Radio TV Complex (RTVC) being composed of multizonal scanners of low (MSL) and moderate (MSM) resolutions. Characteristics are given in table 3.

In 1978 RTVC started to be exploited, that provided regular and timely multizonal information to users in organizations from 16 ministries and departments. The applications of such information gives the opportunity to save some millions of roubles. Development of remote sensing instrumentation has led to new experimental facilieties with additional channels and of high resolution. "Meteor-Priroda" satellite launched in 1980 besides RTVC had on-board experimental complex, characteristics of which are given in table 4.

In 1985 "Kosmos - 1689" Earth resources satellite was launched on sun-synchronous 600 km orbit of 98° inclination. Its primary mission was to acquire timely information on Earth resources for various industries as well as to try out new instrumentation and methods for remote sensing of the Earth and controling of natural environ - ment. Table 5 lists primary instrumentation flown on "Kosmos-1689" satellite Multichannel information may be used to determine characteristics of Earth surface targets and also to solve many applied tasks for the USSR economy.Such advantages of space information as large coverage (inclüding survey of remote non-habitant regions), sufficient resolution, ability to study interrelated components of geosystems have permitted to achive top success in geology, where satellite images are used together with airphotos, geomagnatic data, and ground truth information. Such information support quality of man's activity, improves reliability of delineated structural. li -

Table 3

Primary characteristics of RTVC on "Meteor-Priroda" satellite

Instrument	Spectral range, µm	Resolution, m	Swathwidth, km	Scanning angle, degree
MSL	0,5 - 0,6 0,6 - 0,7 0,7- 0,8 0,8 - 1,0	1000 - 1700	1900	106
MSM	0,58 - 0,7 0,7 - 1,0	140 - 240	1380	90

Table 4

Primary characteristics of experimental payload on "Meteor-Priroda" satellite

Instrument	Spectral band, μm	Resolution, m	Swathwidth, km
Experimental optico-mechanical moderate resolution scanner	0,5 - 0,6 0,6 - 0,7 0,7 - 0,8 0,8 - 1,0	175 x 243	600
Optico-electronics high resolution flat-bed scanner (MS - E)	0,5 - 0,7 0,7 - 0,8 0,8 - 1,0	45 x 60	30 (at coverage of 350 km)
"Fragment" multizonal scanner	0,4 - 0,7 0,5 - 06 0,6 - 0,7 0,7 - 0,8 0,8 - 1,1	80	90
	1,2 - 1,3 1,5 - 1,8	240	
	2,1 - 2,4	480	

Table 5

Primary instruments flown on "Kosmos-1689" satellite

Instrument	Spectral band, µm	Ground resolution,m	Swathwidth, km
Optico-electronic high resolution flat-bed scanner (MS-E)	0,5 - 0,6 0,6 - 0,7 0,8 - 0,9	45 x 30	Under coverage of 600 - 700 km it is 45 (80 when two instruments operate simultaneously)
Five-channel moderate resolution co-nical scanner (MS-MC)	0,5 - 0,6 0,6 - 0,7 0,7 - 0,8 0,8 - 1,1	170	600
	10,4 - 12,6	600	
Two channel moderate resolution (MSM)	0,5 - 0,7 0,7 - 1,0	250	1300

thological elements, speeds up mineral prospecting, favours efforts within most important and prospecting regions. Space information allowed to delineate elements of Earth's crust which are not detectable with routine cartographic methods. Prospecting oil-gas bearing structures detected by means of space data within Dneprovsko-Donetsk lowland were verified with seismic data. Structural situations in near-Caspian sea lowland, in disert regions of Middle Asia were specified to yield more precise estimates for oil-gas contents.

Multizonal information has promoted to make new-in-principle geological maps of USSR territory on 1 : 1500000 - 1 : 5000000 scales. The maps objectively present relationship for large geological structure locations. Multizonal data facilitates solving theoretical and practical problems in geology. Available 1 : 2500000 geological map based on satellite multizonal information is unique. In cartographic activities satellite data helps to save 10-15 % financial expences.

Visible and near-IR data from Earth-resources satellites applied at SCHM afforded to make new techniques to acquire routine information. Now there have been developed methods for computerized processing and interpretation of multizonal scanner data that are now in operational use and allow to provide thematic charts on ice cover boundaries; lake ice situations; sea ice cover; disert grass-land vegetation; forest and tundra fires and cloud formations.

In summer of 1981 338 forest fires on the USSR territory were detected with satellite data and it was used in decision making to extinguish them.

During 1986 summer-time Yakutsk forest protection airbase was daily supplied with satellite photo-compositions from RDRPCs at Novosibirsk and Khabarovsk and with messages on geographycal coordinates of fires detected.

Many DHEEMs (department on hydrometeorology and Earth environment monitoring) use satellite data for ice cover assessment (e.g on Baikal lake and Lake Ladoga). That permits to determine the time of stable ice cover formation and its melting and extend navigation period. Ice cover assessment is extremely important for fisheries and in cargoshipping that allows downing the costs. For example in 1986 navigation of three ships on satellite data-based route between Marjan-м ar and Kolguev Lake under heavy ice situation was non-delayed and conducted without use of icebreaker that saved 250000 rbls. Northern Caspian sea ice charts based on satellite data without air reconnaissance data saved the same year 16000 rbls.

For melioration and water management purposes prereqisites have been created to employ practically computer-based facilities to process air-space sounding data on mirror area of water surface, hydrographic target lengths, various landuse categories.

Satellite data helps to determine areas of agricultural crops of various types; to make decisions on more effective agricultural activities. Percentage accuracy of crop identification is 85 to 95 %. Nevertheless low timeliness and non-sufficient space resolution for agricultural purposes restrict wide use of satellite data for agricultural applications.

MS - E scanner data, obtained 1986 August 3 were used at Ukrainian Resaerch Hydrometeorological Institute (UkrRHMI) in planning and carrying out of study activities on accident effeots at Chernobyl atomic power station.

In 1986 RDPC at Khabarovsk for the first time carried out transmission of map-charts on Oxotsk Sea and Bering Sea ice condition to "Dalryba" objedinenie's ships and to Far Eastern Marine Steam - ship line's vessels.

MDRPC runs timely provision with ice condition map-charts over the Sea of Azov, the Barents Sea to USSRHMC.

Oceanographic satellite system

World oceans have started recently to be observed with "Kosmos-1500" and "Kosmos-1766" satellites. Timely use of remote sensing data has been significantly supported with research-operational experiment on "Kosmos-1500" satellite, which was launched 1983 September 28 on orbit of apogee altitude of 679 km, perigee one - 649 km and 82,6° inclination. The experiment was aimed at following:

- test and fullfilment of new sensors, techniques for world ocean and Earth resources observation for science purposes and various industries applications;
- trying out hardware for data receiption and processing and also methods to process, interprete and apply obtained data;
- acquisition of timely information to be used in various industries interests and to gain experience by users in application purposes.

On-board instruments were as follows:

- X-band side-looking radar of 450 km swathwidth and of 2 km resolution;
- UHF-spectrometer (0,8; 1,35; 8,5 cm wavelength) of 17, 20 and 85 km resolutions, respectively;
- optico-mechanical four-channel scanner (0,5 - 1,0 μm range);
- ice and buyo station - to - satellite data collection and retransmission system of 1600 km coverage.

Major difference between this experiment and early oceanographic ones, conducted in USSR was practical use trend (i.e. regular data provision to users).

Informative satellite system operated both in direct data transmission mode and in preliminary on-board data recording plus subsequent down transmission to ground centers. Information was received and processed at MDRPC and RDRPCs at Novosibirsk and Khabarovsk. Overlapped picture from SLR and MS-L of the same Earth surface site and of the same scale and similar space resolutions was on-board formed within one frame.

Such overlapped data was collected at SADRSs and ships and applied in operational ship navigation on Northern marine route. Radar imagery provides wind speed and direction near sea surface, ice concentration, age; crack, gap availability. Significant advantage of radars is capability for day and hight imaging under any illumination and cloud conditions. That promotes diret radar data transmission to northern, arctic and antarctic SADRPSs and ships. In 1983 October in Eastern Arctic there was heavy ice condition for USSR ship caravan. Radar imagery over these regions from "Kosmos-1500" satellite was frequently transmitted to Northern Marine Traffic Administration and directly to marine activities headquarter. On base of obtained data ice cover of the region was more accurately assessed and ship navigation route was recommended. When "Michael Somov" research ship was under heavy ice condition "Kosmos-1500" radar images were of frequent use to locate an easy passage. Satellite radar information was used also in 1987 summer-time for "Sibir" (Siberia) atomic icebreaker navigation to the North Pole and to NP-27, 29 drifting stations.

Experimental "Kosmos-1500" satellites are being replaced with "Kosmos-1766" orbiters aimed to acquire timely oceanographic data for various industries purposes and international cooperation interests as well as to try out new sensors and techniques for remote sensing of atmosphere and Earth surface. "Kosmos-1766" satellites will be exploited up to mid - 1990s. First "Kosmos-1766" satellite was launched in 1986 july 29 on 650 km orbit of 82,5° inclination. Table 6 gives characteristics of sensors flown on this satellite.

II. 2. Prospects for earth resources and world ocean observation satellite system development

In future space information on Earth resources, natural environment and world oceans will be acquired with single comprehensive satellite system providing frequent global and regional data in vi-

Table 6

Characteristics of sensors flown on "Kosmos-1766" satellite

Instrument	Spectral band, µm	Ground resolution, m	Swathwidth, km
Side-looking radar	3,2 cm	1200 x 1500	450
Scanning UHF Radiometer (RM -08)	0,8 cm	1500 x 20000	550
MS-L	0,5 - 0,6 0,6 - 0,7 0,7 - 0,8 0,8 - 1,1	1900	1900
MS-M	0,6 - 0,7 0,8 - 1,1	370	1100
MS-MC	0,8 - 1,1	500	1150
Non-scanning UHF path polarimeter	3 cm	12° along with orbit 6°perpendicular to orbit	
Data collection platform (DCPs) to satellite transmission and retransmission system		Data transmission from DCPs and their coordinate location	

sible, IR, UHF portions of the spectrum to various industries, as well as to territorial, industrial, government management bodies; designing, explorating and producing organizations.

In comparison to "Kosmos-1689" resources satellite, "Kosmos - 1500", "Kosmos-1766" oceanographic satellites space technology of the future system will be equipped with advanced multispectral visible and IR sensors. UHF instruments (both radiometric ones and radars) will be widely used. Multispectral visible and IR scanning instruments will be presented as combination of high resolution sensors and observing system of moderate and low resolutions. HR scanners will be operated at 0,4 - 12,5 μm band, will have not less than eight spectral channels and swathwidth of about 200 km and ground resolution of 10 - 50 km. Later ground resolution will be as high as 10 m and instruments will be capable of target selecting within 600 km coverage to provide more frequent measurements of Earth regions needed. Moderate and low resolution observing sensors will have a swathwidth of about 1500 km. HR instruments will provide detailed imagery; MR and LR equipment - global information at high frequency.

Analogous principle for combination of HR instruments and observing LR sensors will be maintained when satellites are equipted with radiophysics instrumentation (UHF radiometers, radars etc.) For years to come the single space system for world ocean and Earth resources exploration will provide global information of high resolution at about 8 days frequency and moderate and low resolution data at 2-4 days frequency. Satellite data acquisition and industries' oriented processing will be run at MDRPC and three RCCs under SCHM.

The single space system creation does not mean that all space vehicles of the system will be equipped of the same on-board instrumentation set. It is advisable to make a low-numbered basic complex of instruments (the same for all satellites) and to have special instrument complex used primarily for world ocean study or land target exploration. As USSR and foreign countries experience has shown successful ocean study is possible with UHF radiometers and radars, while land targets being very different are more accurately and easily identified and analysed with multizonal visible and IR data. However it should be noted that most regions of the USSR are located within moderate and high latitudes and applications effectivness of satellite visible and IR data over them is significantly reduced due to cloud presence. Therefore all-weather UHF information is of great importance to urgent practical needs in land target exploration. Moreover, the prospecting use of radar for these purposes is due to high resolution and rather accurate quantitative measurement capability . Additionally at present theoretical studies and numerous experiments have been conducted showing that active UHF remote sensing techniques are capable of providing quality - new information allowing not only to make detailed ice cover maps for polar regions and internal water reservoirs, to determine sea roughness and drifting winds, but also to assess soil moisture, cultivated vegetation biomass; precipitation zones and precipitation rates. Satellite radar data may be successfully used in geology, forest, landplanning applications.

Future space system when observing world oceans will provide frequent data on SST, roughness, drifting winds, ice cover, water mass circulation (frontal zones, vortexex, upwelling currents and others), sea surface pollution, water colour, shore line deformation. Satellite data on Earth resources will be widely applied for research and operational interests of various industries of the USSR.

In the later half of 1990's on-board informative systems will be supported with multichannel programmable high spectral and space resolution spectrometers capable of on-board processor-aided selecting of approciate spectral channels, spectral and space resolutions and other parameters.

Conclusion

In the years to come and later up to mid - 1990's two operational satellite system (i.e. single space system for hydrometeorological data provision of USSR economy and satellite system for earth resources, world ocean exploration and natural environment monitoring) will be developped and advanced. Such approach however does not mean that designing, constructing and exploiting of these system will be conducted independently. To solve in most effective way research and operational tasks complex use of remote sensing data from different satellite systems is planned. Even now hydrometeorological data provision is supported with meteorological satellite data and "Kosmos-1500", "Kosmos-1766" oceanographic satellite data; agrometeorological data provision is supported with "Meteor-Priroda" Earth resources satellite data and "Kosmos-1689" data. Meteorological satellite information is successfully applied for geology, agriculture, oil and gas industry and other industries purposes.

As remote sensing techniques and hardware are developed and advanced as well as on-board data processing analyse and compression methods and equipment, and also ground data processing and applications technical means there will be feasibility to create single comprehensive operational satellite system for Earth observations.

Annex to the Meteosat-4 Calibration Report, and operational calibration of the Meteosat water vapour channel

ANNEXE TO THE METEOSAT-4 CALIBRATION REPORT

OD/MEP/MET (July 1989)

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1.0 INTRODUCTION

For some years the Calibration Report, issued on a quarterly basis, has contained a considerable amount of information which remains unchanged throughout the life of the satellite, e.g. spectral response data. In order to avoid repeating such information at regular intervals it has been decided to produce this Annexe to the Calibration Report. The Calibration Report will continue to be issued on a quarterly basis but, in general, will only contain information which is subject to change, e.g. black body calibration data and calibration coefficients. All information which is of a permanent or semi-permanent nature will be contained in this Annexe. In addition, the reader will find within the following pages a description of the on-board black body calibration mechanism and the methods used within the Meteorological Information Extraction Centre (MIEC) to derive the absolute calibration coefficients of the infrared and water vapour channels. Updates to this document will be issued as necessary and provided to all current recipients of the Calibration Report.

2.0 BLACK BODY CALIBRATION

The black body calibration (BBC) mechanism on-board METEOSAT-4 differs from that on the pre-operational METEOSAT satellites, not only in its modes of operation but also, whenever a BBC sequence is initiated, data are obtained for both the IR and WV channels. The two main methods of performing a BBC are termed the 'nominal' and 'space' calibration modes, although variations of these two methods also exist. In addition, two black bodies are located within the radiometer. One is known as the 'cold' black body and assumes the ambient temperature of the spacecraft, the other is known as the 'hot' black body and can be heated to approximately 50^0C above the temperature of the 'cold' black body. The temperature of the two black bodies is expected to be in the range from 278-308K for the 'cold' black body and from 328-358K for the 'hot' black body.

A BBC sequence can only be triggered at the end of a reverse scanning (retrace) of the radiometer and nominally this will take place at the end of slots 12 and 36. At the present time the possibilities offered by the on-board black body calibration mechanism are being investigated and although all relevant data will be included in the Interpretation Data block of the High Resolution dissemination formats and in the Calibration Report we suggest that users make use of the MIEC calibration coefficients for quantitative analysis. We would also be interested to hear of any use which users are making of the black body calibration data. All BBC information will be tabulated in the Calibration Report.

2.1 Modes of Black Body Calibration

2.1.1 The Nominal Calibration Mode

In the first step of a nominal mode BBC a mirror, driven by a motor, is moved into a position such that the radiation emitted from the 'cold' black body is viewed by the respective detectors. The 'cold' black body is viewed for about 76 s and this provides the reference signal level (DC restore level) above which the response of the 'hot' black body will be measured. After viewing the 'cold' black body the mirror is moved to view the 'hot' black body. The recorded counts, which represent the difference in temperature of the two black bodies, and the temperature of the two black bodies are telemetred to the ground, thus a relative calibration slope can be derived from the information provided. In theory it is possible to perform this mode of calibration without heating the second black body, however, since the difference in temperature of the two black bodies would be very small it is unlikely that this method will ever be used in practice.

2.1.2 The Space Calibration Mode

This mode of BBC was originally forseen as a back-up mode in the situation where the 'hot' black body heater had failed, however, in practice space calibration can be performed as required. In this mode the reference level is first obtained by viewing space. The mirror is then moved into the position for viewing the 'hot' black body which, for a space calibration, is not normally heated but assumes the ambient temperature of the spacecraft; heating of the 'hot' black body for a space calibration is, however, permissible. The recorded count effectively represents the count corresponding to the temperature of the 'hot'black body.

2.1.3 Gain Changes

2.1.3.1 Calibration gain changes

As has been indicated above, the 'hot' black body can be heated in either the nominal or space calibration modes. Because of the relatively high temperature of the 'hot' black body, when it is heated, a calibration gain change has to be activated during the reverse scanning of the radiometer immediately prior to the BBC. If this calibration gain change was not made the detectors would be saturated, resulting in meaningless information. Effectively the analogue signal from the detectors is divided by two for the IR channel and eleven for the WV channel, before being converted into a count. It is likely that the calibration gain change will also have to be activated during a normal space calibration to avoid saturation of the WV detector.

2.1.3.2 Image gain changes

Each of the spectral channels can be operated at one of sixteen different gain levels (0 - 15). These gain levels are used to obtain the optimum dynamic range (0 - 255) for each spectral channel and are adjusted as required. The image gain level adjustment is particularly useful for compensating the effects of contamination (see Section 4) and detector ageing.

At the start of operations of a particular satellite the gain level is selected for each spectral channel such that saturation, i.e. counts of 255, either does not occur or is minimal. Since the gain steps have an approximate ratio of 1.2 an increase of gain would normally be made when the maximum count at slot 24 falls to less than 212. In general, the user should not be concerned with image gain changes in terms of calibration since the effects of any gain change will be compensated by an adjustment of the MIEC calibration coefficients. The operational gains will be tabulated in the Calibration Report.

3.0 MIEC Calibration Techniques

Absolute calibration of the different spectral channels is essential in order to perform any quantitative analysis of the METEOSAT image data. The on-board black body calibration device is not suitable for absolute calibration since the optical path of the radiation during normal imaging is different from that when performing a black body calibration. The on-board calibration only provides information on the relative changes in response of the infrared and water vapour detectors thus some form of vicarious calibration has to be used to obtain absolute calibration coefficients for these spectral channels. This section provides information on the techniques currently used within the MIEC.

3.1 Absolute Calibration of the IR Channel

Within the MIEC, an IR calibration coefficient is calculated every three hours. The method used is based on a comparison of METEOSAT sea surface temperatures (SST) and an independent set SST observations obtained from ECMWF but originally produced by the National Meteorological Center (NMC) in Washington D.C.

In the comparison method the first step is to filter the SST derived for individual segments from a single METEOSAT image. The filtering takes the form of eliminating all segment SST values where the segment contained less than 80% sea pixels and the standard deviation of the count is greater than 1.5; those segment values that remain are used in the comparison. For the selected segments the radiance at the top of the atmosphere is calculated using the operational MIEC radiation scheme (Schmetz 1986). Input data are in the form of atmospheric temperature and humidity profiles obtained from ECMWF short-term forecasts for the grid point nearest to the segment centre; the surface boundary value is obtained from the NMC surface temperature analysis. The corresponding count for these radiances is calculated using the current calibration coefficient and compared with the collocated measured count of the METEOSAT SST. If the difference exceeds a certain threshold the collocated pair is eliminated from the calculation of the new calibration coefficient.

The remaining collocated pairs of calculated radiances and measured counts are combined to calculate a mean radiance, $\bar{L}$, and a mean count, $\bar{C}$. The calibration coefficient α_{IR} is then calculated from the linear relationship:

$$\alpha_{IR} = \frac{\bar{L}}{(\bar{C} - C_0)}$$

The space count C_0 is obtained from the spaceview as seen by the radiometer in the four corners of the image.

Although the infrared calibration coefficient is calculated every three hours it is only updated as necessary, usually not more than once per day. The major criteria for updating the calibration coefficient is related to the difference between the current operational value and a mean of the recently calculated values. During periods of detector contamination more frequent updates to the calibration coefficient are likely to be necessary. A history of the infrared calibration coefficient is documented in the Calibration Report.

3.2 *Absolute Calibration of the WV Channel*

A detailed description of the method used to determine an operational calibration coefficient of the METEOSAT water vapour channel is given by Schmetz (1989). In principle, the technique is similar to that used for the infrared channel but calibration coefficients are only calculated twice per day.

The method of calibration makes use of radiosonde profiles. These are received at ESOC from the Regional Telecommunication Hub (RTH) of the Global Telecommunication System (GTS) of the World Meteorological Organisation (WMO) at Offenbach, Federal Republic of Germany. The temperature and humidity profiles of the radiosonde ascents at 0000 UT and 1200 UT are used as input to the ESOC radiation scheme to calculate radiances at the top of the atmosphere. Collocated counts from the METEOSAT water vapour channel provide the other input to the calibration technique. Before calculating the calibration coefficient the radiosonde data are screened by converting the calculated radiances into counts, using the current calibration calibration coefficient, and comparing them with the measured counts. If differences between the pseudo-counts and measured counts exceed a certain threshold, the radiosonde profile is rejected. The remaining collocated pairs of calculated radiances and measured counts are then used to calculate the calibration coefficient in the same manner as used for the infrared channel.

Updates of the water vapour calibration coefficient are made in a similar way as for the infrared channel and are documented in the Calibration Report.

3.3 Calibration of the VIS Channel

Calibration of the visible channel is not performed by ESOC. For METEOSAT-1 and -2 external researchers have performed calibration of the visible channel (Koepke 1982, Kriebel 1981). Arrangements have been made by EUMETSAT to calibrate the visible channel of METEOSAT-4 and the results will be made available to users when they become available.

4.0 RADIOMETER CONTAMINATION

Contamination of the infrared detectors (IR and WV channels) by the condensation of water vapour molecules on the detectors, in the form of a thin layer of ice, has been a feature of previous METEOSAT satellites. This will also be a feature of the operational series of satellites and will result in a loss of infrared and water vapour imagery during periods of about two days when it becomes necessary to decontaminate the detectors.

Contamination of the detectors is more evident during the early years in the life of a satellite and gradually declines as more and more of the water vapour, carried into orbit with the spacecraft at the time of launch, is evacuated from the spacecraft due to successive decontaminations. Contamination of the detectors usually commences in the middle of October, gradually accelerating to a maximum around the winter solstice, before declining once again. Contamination is not normally evident between the spring and autumn eclipse periods.

The effect of contamination is to reduce the sensitivity of the infrared detectors and hence the dynamic range of the IR and WV spectral channels. To a certain extent this can be compensated by increasing the on-board gain, however, continually increasing the gain also reduces the signal-to-noise ratio of the channels and decontamination eventually becomes necessary.

Decontamination is performed by heating the radiometer cooler and thus raising the temperature of the detectors. The infrared detectors normally operate at a temperature of about 90K (-183^oC); the heating of the cooler raises this temperasture to about 305K (32^oC) thus melting the ice and evaporating the water vapour molecules. Unfortunately, experience has shown that a single decontamination does not eliminate all the water vapour molecules present within the body of the spacecraft, even if the decontamination is performed over a week or more. Thus, particularly during the first year in orbit, decontamination has to be performed several times during the Northern Hemisphere winter period.

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Operational calibration of the METEOSAT water vapor channel by calculated radiances

Johannes Schmetz

A method is presented for calibrating the water vapor channel (5.7–7.1 μm) of the geostationary meteorological satellite METEOSAT by radiative transfer calculations. Radiances are calculated from the temperature and moisture profiles of conventional radiosondes and linearly related to collocated satellite measured digital counts. Collocations are considered only for areas with neither medium nor high level cloud. Radiosonde data are routinely received twice per day (1200 and 2400 UT). Radiosonde profiles from an 8-day period in May 1988, and simultaneous Meteosat-2 water vapor measurements are analyzed. The total of 340 collocations provides a calibration coefficient with a precision of 2% assuming a 95% confidence. A preliminary analysis of calibration coefficients of the recently launched METEOSAT-3 shows a significant increase of 6% over a period of 48 days in Sept./Oct. 1988. The calibrated water vapor radiances are operationally used to estimate the upper tropospheric humidity field and to correct the height assignment of semitransparent clouds.

I. Introduction

The quantitative extraction of meteorological information from satellite radiometer data requires an absolute calibration of the radiometer. The calibration establishes a functional relationship between the satellite measured digital counts and the physical unit radiance. In principle, a calibration can be derived from prelaunch data. However, in practice such a relationship is of limited use only because the radiometer response may change while in-flight. For thermal IR measurements this is caused by changes in detector sensitivity due to aging and water vapor contamination or by optical degradation of the mirror and filter system. Temperature changes also play a role due to the nonperfect properties of the optical system. Obviously that necessitates a frequent update of an actual calibration.

Absolute in-flight calibration in the thermal IR would be possible with a blackbody source put in front of the radiometer's primary optics. Aboard geostationary satellites the large size of the main telescope prevents such a direct calibration (aperture ~40 cm for METEOSAT). The METEOSAT satellites do have a so-called blackbody calibration facility for the IR channel (10.5–12.5 μm), and on the future European geostationary satellites [METEOSAT-4 and subsequent satellites in the METEOSAT operational program (MOP)] this will be extended to the WV channel (5.7–7.1 μm). This device, however, cannot be considered for absolute calibration since viewing the internal blackbody, first, does not include the main telescope and, second, uses a mirror which is not included in the optical path of normal imaging. Therefore, the onboard blackbody is only a valuable tool for monitoring detector response.[1]

An alternative to a true in-flight calibration is the vicarious calibration where portions of the earth with known radiative exitances are the calibration source. The vicarious calibration can be conducted in two ways,[2] either by comparison of satellite counts to calibrated radiometric data from similar channels aboard another satellite or an aircraft[3–6] or with the aid of computed radiances using actual atmospheric parameters as input to the radiative transfer model.[2,7–10]

The latter method has been applied to the water vapor channel of METEOSAT, but those studies were confined to the use of a single atmospheric profile measured by an aircraft[7] or to a small set of radiosondes from two days over a limited area in Europe.[8]

This work describes the vicarious calibration of the METEOSAT water vapor channel by means of an efficient radiative transfer model as it is conducted operationally at the European Space Operations Centre (ESOC). The structure of the paper is as follows: Section II describes the satellite image data. Section III outlines the radiative transfer calculations and the radiosonde profile data used as input. Sections IV and V consider the operational calibration and an al-

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ternative calibration method, respectively. Section VI provides example results from an 8-day period for METEOSAT-2, which was operational until mid Aug. 1988. The conclusions contain an example of calibration monitoring over a 48-day period during the early days of METEOSAT-3.

II. Satellite Data

The geostationary METEOSAT satellites observe the earth with an imaging radiometer:

in the solar spectrum (VIS) between 0.4 and 1.1 μm;

in the infrared window region (IR) between 10.5 and 12.5 μm;

in the water vapor absorption band (WV) between 5.7 and 7.1 μm.

Images are taken at half-hourly intervals with a spatial resolution at the subsatellite point of 2.5 × 2.5 km for the VIS and 5 × 5 km for the IR and WV channels.

The radiometric resolution of the data for individual pixels is 8 bits for the IR and 6 bits for the WV and VIS channels, respectively. Note that for the future MOP satellites the radiometric resolution of both the VIS and WV channels will be extended to 8 bits. For the WV channel, which is of interest here, a one-count change corresponds to a change in brightness temperature of ~0.9°C at a scene temperature of 260 K assuming the presently operational gain setting. The $NE\Delta T$ is ~0.6°C for the operational detector temperature of 90 K.

At the European Space Operations Centre (ESOC) meteorological products are operationally derived for use in numerical weather prediction and climatological research.[11] Most products are derived for so-called segment areas of 32 × 32 IR or WV pixels. The operational calibration described here uses satellite water vapor counts which are also meaned over 32 × 32 pixels. In the processing the mean values of the original 6-bit data are expanded to 8 bits. Note that in the following all WV counts refer to 8-bit data.

The WV channel has two major applications within the meteorological processing at ESOC: (a) to estimate the upper tropospheric relative humidity field[12] and (b) for the height assignment of semitransparent clouds.[13] The latter is especially important for a correct height attribution of cloud motion winds derived from successive IR images.[14] Such quantitative exploitation of WV data necessitates an adequate calibration which must be performed in a continuous operational mode to capture changes of the calibration coefficient with time.[15]

III. Radiance Calculations

A. Radiative Transfer Model

Assuming a plane-parallel nonscattering atmosphere with thermodynamic equilibrium and an azimuthally symmetric radiation field, the spectral radiative transfer may be expressed as[16]

$$\mu \frac{dL_\lambda(\delta,\mu)}{d\delta} = B_\lambda(T) - L_\lambda(\delta,\mu), \tag{1}$$

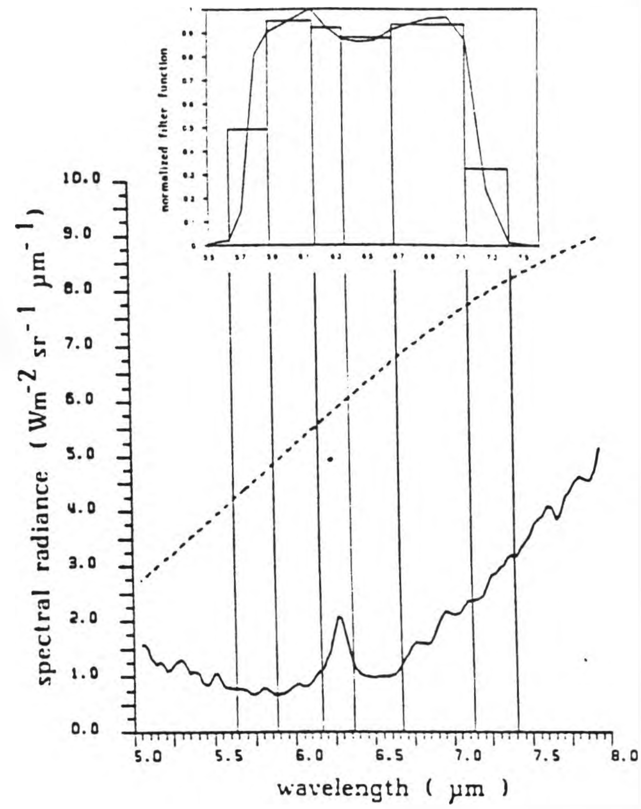

Fig. 1. Outgoing radiance at the top of a tropical standard atmosphere for nadir view. The dashed line is the Planck function for surface temperature. The vertical bars indicate the spectral bands of the radiation model. The inset in the upper part depicts the METEOSAT-2 water vapor channel response function, which is normalized to the maximum value 0.52.

where L_λ is the spectral radiance, μ is the cosine of the zenith angle, δ is the optical depth, which increases along the direction of the radiance, and B_λ is the spectral Planck function dependent on the temperature T. λ denotes the dependence on wavelength.

The operational radiation model is based on an analytical solution to the Schwarzschild equation [Eq. (1)], which has already been described with application to the METEOSAT IR channel.[17] Here it should suffice to recall the result: Allowing the Planck function $Bp(T)$ to vary linearly with optical depth, Eq. (1) is solved by

$$L_\lambda(\delta,\mu) = C \exp\left(\frac{-\delta}{\mu}\right) + B_\lambda^b + (\delta - \mu)\frac{(B_\lambda^t - B_\lambda^b)}{\delta^{tot}}, \tag{2}$$

where B_λ^b and B_λ^t are the Planck functions at the bottom and top of a layer with the optical depth δ^{tot}. C is a constant determined by the boundary condition. Starting at the surface the radiative transfer through a vertically inhomogeneous atmosphere is simulated by solving Eq. (2) successively for all layers. As a boundary condition at the surface we adopt an emissivity of 1 for the sake of simplicity since the surface contribution to the outgoing radiance is small.[12]

The radiation model resolves the METEOSAT WV channel with six spectral intervals as indicated in Fig. 1. The spectral bands were chosen under the constraints of, first, minimizing the number of intervals to enable the operational application with limited computer power and, second, to model adequately both the spectral response of the WV channel and the spectral characteristics of the radiance exiting the earth's atmosphere. Figure 1 shows the radiance spectrum at the top of a tropical standard atmosphere,[12] and the inset in the upper part illustrates the normalized WV response function of the radiometer aboard METEOSAT-2.

The water vapor transmittance in the six spectral bands is computed from an exponential sum fit[18] to LOWTRAN-5 results.[19] Gaseous absorbers other than water vapor can be safely neglected with radiance errors of <0.5% as shown by Poc *et al.*[8] A detailed test of the radiation model has been presented by Schmetz and Turpeinen,[12] and good agreement has been found with other model results.

B. Radiosonde Data

Radiosonde profiles are routinely received at ESOC via the Global Telecommuncations System (GTS) of the World Meteorological Organization (WMO). The temperature and humidity profiles of radiosondes at 1200 and 2400 UT are employed as input to the radiation model to calculate theoretical radiances. The radiosonde data are available at standard levels of 1000, 850, 700, 500, 400, 300, 250, 200, 150, 100 hPa for temperature and up an altitude of 300 hPa for the humidity. Above 300 hPa the relative humidity is assumed to decrease linearly with pressure to 0% at 100 hPa. The linear extrapolation of relative humidity certainly is a compromise. The approach, however, seems justified, particularly in view of the scarcity of humidity reports above 300 hPa. Furthermore, the outgoing radiance in the WV channel is largely determined by the atmospheric column between ~600 and 300 hPa.[8,12,20] A complete radiosonde profile for that height interval is a precondition for its use in the calibration. Concerning the linear extrapolation it is also interesting to point out that Rockel[21] has indeed found a nearly linear decrease of mean relative humidity with pressure at high altitudes (above 400 hPa) in a global humidity analysis of the European Centre for Medium Range Weather Forecast (ECMWF) for Mar. 1984.

The vertical grid specified by the radiosonde data is not adequate for the vertical integration of the radiative transfer equation. Therefore, a new 14-level grid is created by interpolation. The temperature is interpolated logarithmically in pressure, and the water vapor mixing ratio is interpolated by keeping the precipitable water constant.

Routine radiosonde humidities may be erroneous at higher altitudes[22] and cannot be used without quality control. A simple but efficient approach is adopted to screen the incoming radiosonde data: The radiances calculated from a radiosonde profile are converted into theoretical counts (pseudocounts) using the presently valid calibration. The pseudocounts are then compared with the actually measured counts, and a radiosonde profile is rejected if the difference exceeds a certain threshold. The threshold is made dependent on the mean relative humidity in the atmospheric column between 600 and 300 hPa. Thresholds of 32 and 16 counts (8-bit counts) are taken for relative humidities below and above 50%, respectively. The split into more than one humidity class is suggested by the nonlinear response of the outgoing radiance to changes in relative humidity. While small changes at low relative humidities lead to comparatively large changes in the radiance field, the WV band saturates at higher humidities which implies a much lower sensitivity of radiances to humidity, e.g., Ref. 12.

Obviously the simple quality check of radiosonde data also rejects radiosondes with outliers in the temperature profile. On the average <5% of the possible collocations are rejected due to the above quality control.

IV. Calibration Method

The radiance L_{sat} measured by the satellite radiometer produces a voltage which is linearly converted into counts aboard the satellite. Prelaunch tests have shown that the radiance-to-voltage relationship is linear within better than 2%. Thus the measured radiance L_{sat} may be associated with a count via a linear relationship:

$$L_{sat} = \int_{\lambda_1}^{\lambda_2} L_\lambda f_\lambda d\lambda = \alpha_{WV}(C - C_0), \tag{3}$$

where λ_1 and λ_2 are the cutoff wavelengths of the response function f_λ, α_{WV} is the calibration coefficient, C is the measured count, and C_0 is the count at space view.

The operational method of calibration can be summarized as follows:

(1) Radiances L_{sat} are computed with the radiative transfer model using temperature and humidity profiles from conventional radiosondes as model input. Radiosonde data undergo a quality control as described in Sec. III.B.

(2) A radiance L_{sat} is related to measured count C. The measured count is a mean over a segment of 32 × 32 pixels in which the radiosonde is located. The segment must contain neither medium nor high level clouds. The information on the presence of clouds is readily available in the operational processing system from a multispectral image analysis.[23]

(3) All collocations are combined to calculate the mean radiance $\bar{L}$ and the mean count $\bar{C}$. Then the water vapor calibration coefficient α_{WV} is calculated from

$$\alpha_{WV} = \frac{\bar{L}}{\bar{C} - C_0} = \frac{\sum_{i=1}^{N} L_{sat,i}}{\left(\sum_{i=1}^{N} C_i\right) - NC_0}, \tag{4}$$

where N is the number of collocations. The space count C_0 has been determined from space view,[24] and it is $C_0 = 11$ for the METEOSAT-2 satellite and the period under study.

(4) Calibrations are performed twice per day with

radiosondes from 1200 and 2400 UT. The processing is confined to the 55° circle arc around the subsatellite point.

(5) The actual calibration coefficient used in the operational software is only updated if the calibration coefficient obtained from the most recent N collocations differs by more than 1.5% from the actual value. This is to avoid too frequent changes which merely reflect noise mainly from the radiosonde data. This point is elaborated in Sec. VI. At present a value of ~250–300 is used for N. Changes to the actual calibration used in the operational product retrieval are introduced manually and also observe the recent trend in the data. An automatization of the updating is envisaged in the future.

The condition in (2) that neither medium nor high level cloud may be present in a segment area is mandatory because medium, and high level clouds would contaminate the measured count while the calculated radiance pertains to clear sky. The occurrence of low level cloud (below altitudes of 700 hPa) is accepted since the contribution of the lower troposphere to the outgoing WV radiance is small.[12]

Figure 2 shows an example distribution of collocations on 2 May 1988, 1200 UT. Collocations are indicated by the WV brightness temperature (in kelvins) computed from the radiosonde profiles. It is interesting to see the warmest brightness temperature appear over the subtropical South Atlantic (Ascension Island) where prevailing subsidence of air leads to a relatively dry and warm upper troposphere.

Figure 2 also indicates that the bulk of collocations is from the European/Mediterranean region, although no collocations were acceptable over Western Europe on this occasion due to the occurrence of upper level cloud. Note that two European radiosondes are not plotted to avoid overlapping numbers. Statistics on the geographical distribution have shown that more than 50% of all collocations originate from the European/Mediterranean region, which reflects the density of the radiosonde network there. About 10% of the collocations were from the Middle East, 15–20% from Africa, and the remainder from South America, North and South Atlantic, and the Indian Ocean.

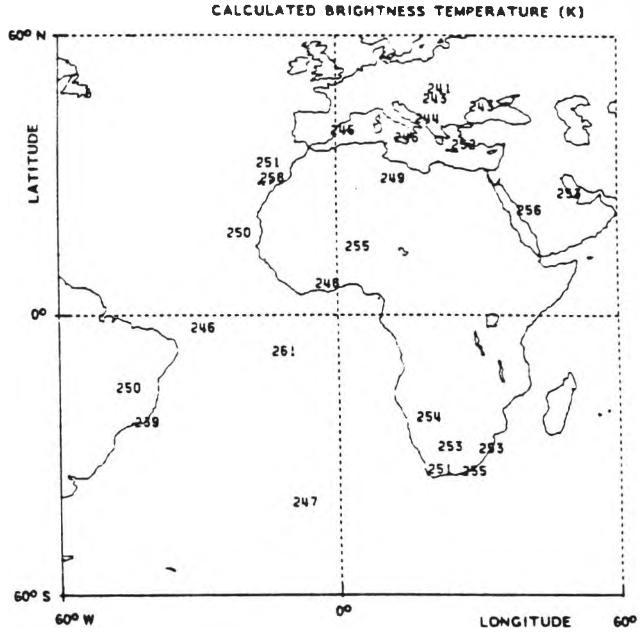

Fig. 2. Water vapor brightness temperatures computed from accepted radiosonde temperature and humidity profiles for 2 May 1988, 1200 UT. Values are plotted at the geographical location of a radiosonde station.

V. Two Parameter Regression

The operational calibration described in the previous section is a one-parameter regression, which exploits the *a priori* knowledge of the linear response of the radiometer to incoming radiation. The intercept of the calibration line with the ordinate is given by the count at space view. Hence the slope or calibration coefficient is solely dependent on the gravity center (mean values) of all collocations, and no consideration is given to the actual distribution of data points.

A two-parameter regression on the collocation data can evaluate the adequacy of the operational approach. In particular, one may expect the two-parameter regression to provide similar values for the calibration coefficient and space count. Instead of using a standard linear regression which minimizes the squared vertical or horizontal distances of the data points to the regression line, a linear relationship is obtained from the first principal component of the correlation matrix of the collocation data.[25] The slope of the first principal component may be calculated from

$$\alpha_{WV} = \frac{\sigma_L}{\sigma_C}, \tag{5}$$

where σ_L and σ_C are the standard deviation of the radiances L and the WV counts C, respectively. An estimate for the space count immediately follows from

$$C_0 = \bar{C} - \frac{\bar{L}}{\alpha_{WV}}. \tag{6}$$

In Sec. VI the slope α_{WV} is referred to as the optimum slope or the optimum calibration coefficient as opposed to the operational calibration coefficient α_{WV}.

VI. Results

Data are presented from an 8-day period (1–8 May 1988) comprising 340 collocations. Figures 3(a)–(d) show the results of the sixteen calibration runs using only radiosonde data from a single synoptic date. Each four-panel figure comprises two days of data. The collocations are plotted as calculated radiance (in W m^{-2} sr^{-1}) vs measured satellite water vapor count. In each panel the number of collocations and the linear regression coefficient are given. The solid line corresponds to the operational calibration described in Sec. IV, and the dashed line pertains to the first principal component. Figures 3–6 indicate that the relationship between calculated radiances and measured counts is linear in agreement with prelaunch tests. The standard deviation of the slopes α_{WV} over the

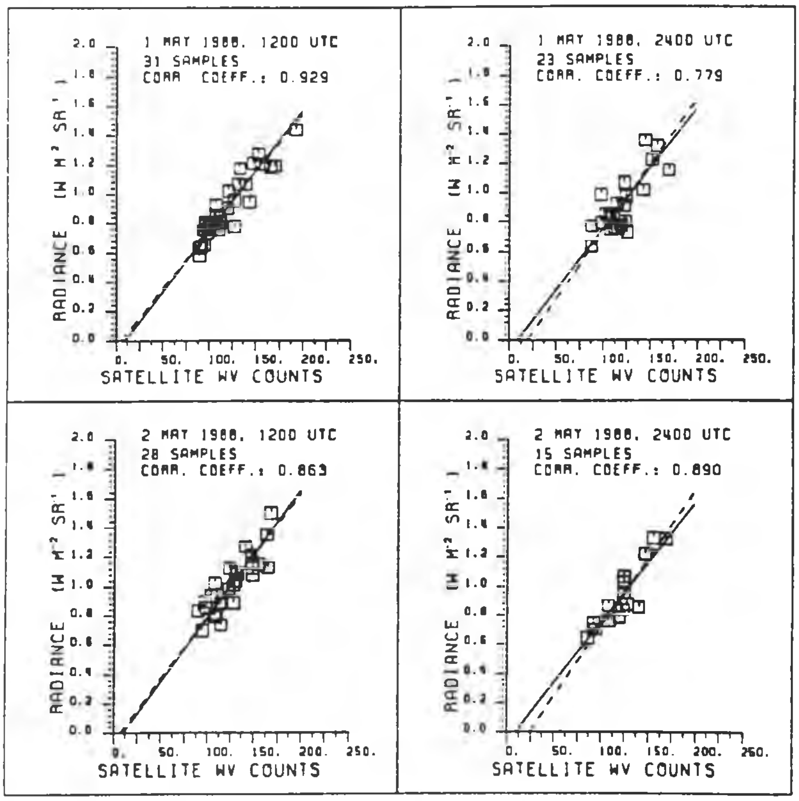

Fig. 3. Scatter plot of collocations (computed radiance and measured count) for 1 and 2 May 1988 at 1200 and 2400 UTC, respectively. The number of data points and the linear correlation coefficient are also given. The solid line corresponds to the operational calibration as described in Sec. IV, and the dashed line depicts the first principal component.

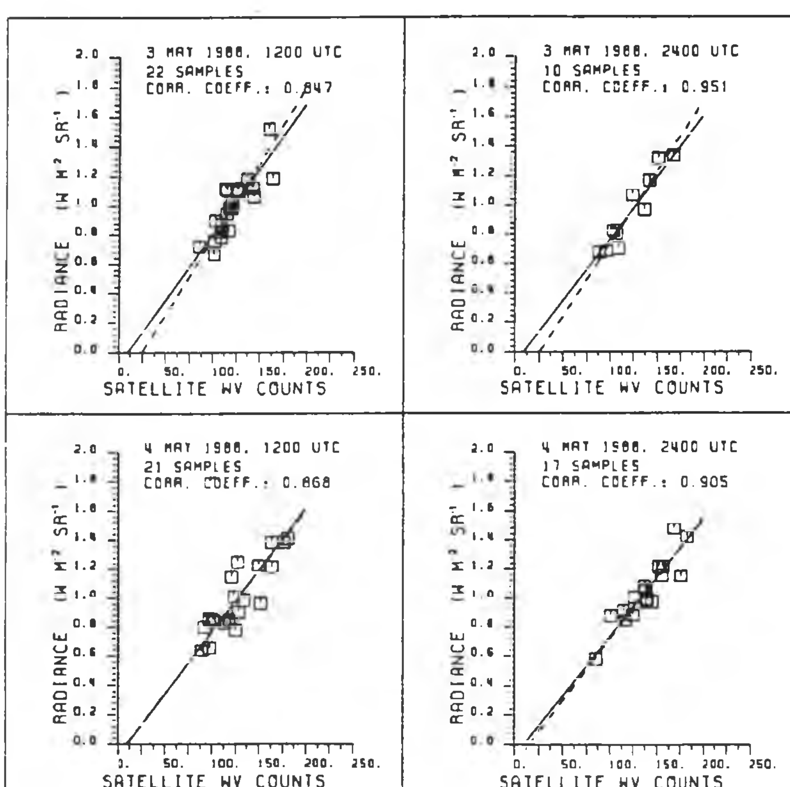

Fig. 4. As Fig. 3 except for 3 and 4 May 1988.

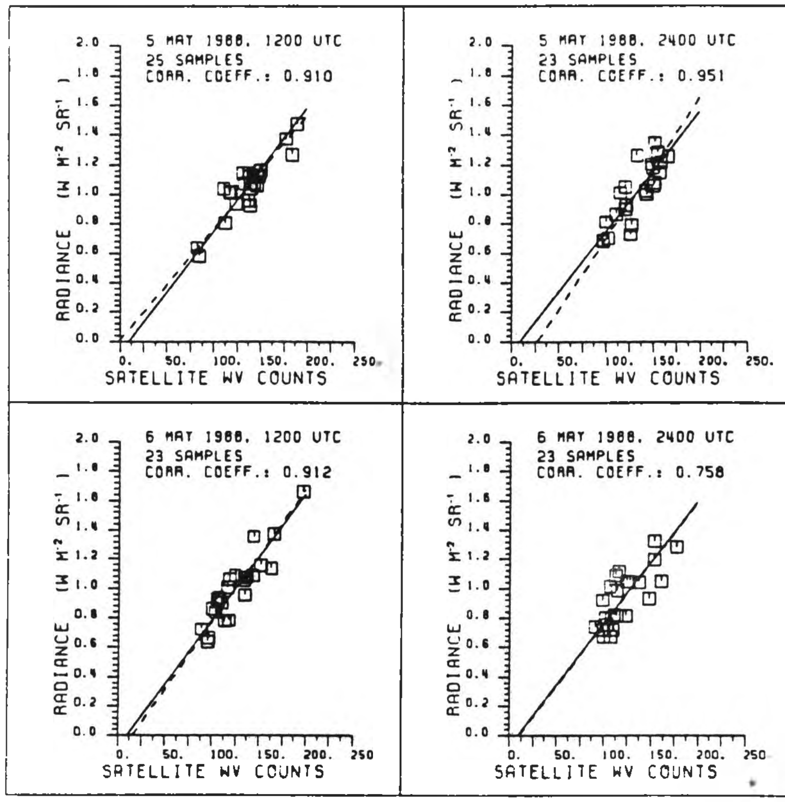

Fig. 5. As Fig. 3 except for 5 and 6 May 1988.

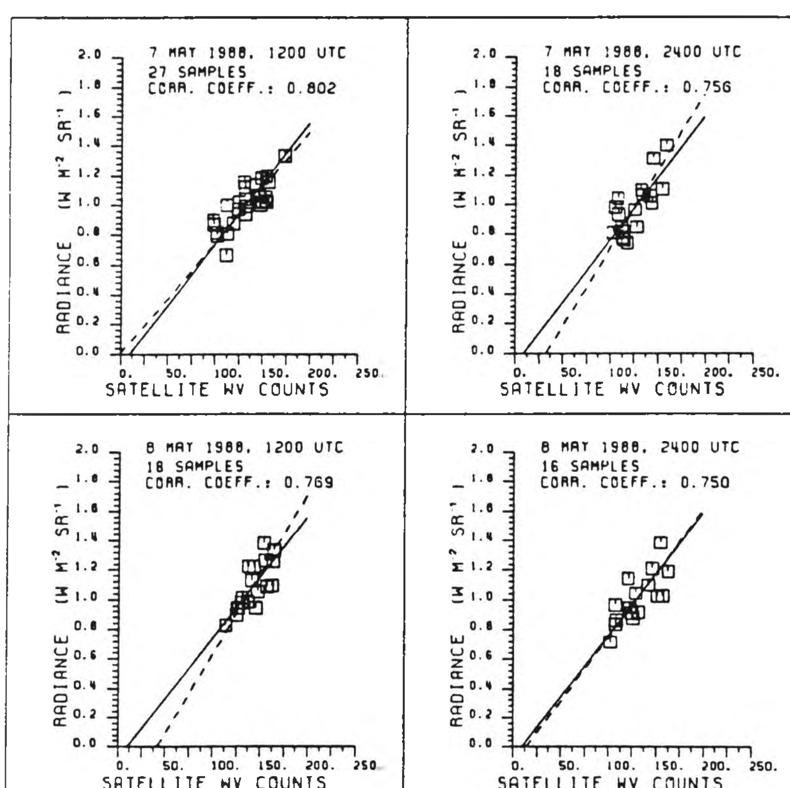

Fig. 6. As Fig. 3 except for 7 and 8 May 1988.

sixteen individual runs is 2.5%, while the standard deviation of the optimum regression coefficients α_{WV} is as large as 11%.

The large dispersion of the optimum slopes from the first principal component can be chiefly attributed to the noise in the radiosonde data, presumably due to erroneous but accepted radiosonde profiles. Furthermore, the geographical distribution of the radiosondes accepted for a specific synoptic date varies considerably. Since the radiosondes from different countries may have different biases that will also appear as fluctuation of the calibration from run to run. In a future study it is planned to monitor the geographical distribution and the impact of such radiosonde dependent biases.

To reduce the noise collocations data were accumulated over the eight days. Figure 7 shows the scatter plot of 340 collocations available for that period. Again the solid line depicts the calibration equation resulting from the operational one-parameter regression, which reads

$$L_{sat} = 0.00841(C - 11.0). \quad (7)$$

The two-parameter fit via the principal component analysis yields

$$L_{sat} = 0.00863(C - 14.1), \quad (8)$$

$\alpha_{WV} = 0.00841$ W m^{-2} sr^{-1} and $\alpha_{WV} = 0.00863$ W m^{-2} sr^{-1} agree within 2.5%. The space count $C_0 = 14.1$ is also in good agreement with the value $C_0 = 11.0$ as determined from space viewing by Martinez.[24] Equation (8) explains 92% of the variance of the collocation data.

The difference between Eqs. (7) and (8) is quantified in Table I in terms of radiances and equivalent brightness temperatures. For three different count values the corresponding radiances and brightness temperatures T_{BB} are given. At high temperatures we find a slight underestimation by the operational method compared with the first principal component. At low brightness temperatures the trend is reversed, and the operational approach leads to T_{BB} values which are ~1°C higher.

The precision of the operational vicarious calibration can be estimated from the variance of the mean value which determines the slope of the calibration line together with the fixed value for the space count. Assuming 95% confidence one can estimate a 2% precision of α_{WV} from the 340 collocations. Since this order of precision is desirable for the operational system, collocation data accumulated over a couple of days are used for the decision on whether the actual calibration coefficient needs to be changed (see Sec. IV).

As for the absolute accuracy of the calibration it is difficult to provide an estimate. The two major sources for a possible bias are the radiosonde profile data and the radiative transfer model, although the latter was shown to yield good agreement with other models.[12] An *in situ* calibration seems to be the only way to clarify that point. On future satellite missions new concepts for the in-flight calibration of large-aperture radiometers[26] may substantiate as practical solutions to a direct blackbody calibration.

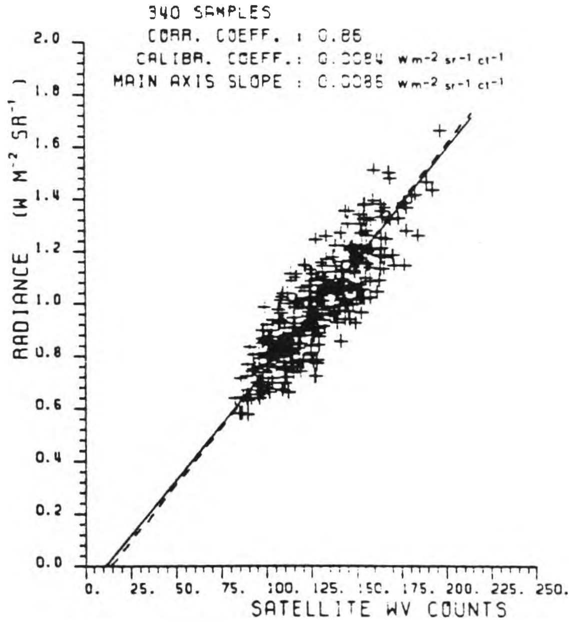

Fig. 7. Scatter plot of all collocations for the 1–8 May 1988 period. The solid line shows the operational calibration method [Eq. (7)] and the dashed line the first principal component [Eq. (8)].

VII. Summary and Conclusion

A method is described of vicarious calibration of the METEOSAT water vapor channel by calculated radiances. Radiances are computed with a radiative transfer model from the temperature and humidity profiles of conventional radiosondes and related to measured water vapor counts. Radiosonde profile data are received routinely twice per day at 1200 and 2400 UT. The method is operationally in use at the European Space Operations Centre where METEOSAT is operated.

Collocation data from an eight-day period are analyzed. Calibration coefficients are determined with the operational one-parameter regression, which exploits the *a priori* knowledge of the space view count and a two-parameter regression using the first principal component. The operational method shows a much higher stability for runs with small data samples. Good agreement between the operational and two-parameter method is obtained when collocations are accumulated over the full 8-day period yielding a total of 340 collocations. This agreement supports the validity of the simplified operational one-parameter regression. It is also concluded that collocation data

Table I. Brightness Temperature Corresponding to a WV Count Computed from Eq. (7) (T_{BB}) and Eq. (8) (T_{BB}), Respectively

WV count	T_{BB} (K)	T_{BB} (K)
200	262.9	263.1
100	241.0	240.9
50	220.8	219.6

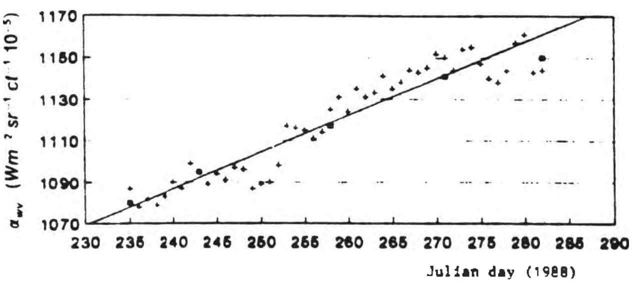

Fig. 8. Time series (22 Aug.–8 Oct. 1988) of the water vapor calibration coefficient for METEOSAT-3 (crosses) as suggested from daily calibration runs using data accumulated over the last four days. The solid line shows the trend, and solid squares depict the actual calibration coefficient used in the operational system.

need to be accumulated to yield a statistical sample large enough to provide sufficient precision. The data of the period studied suggest a precision of the operational calibration coefficient of 2% assuming 95% confidence. Therefore, the decision on whether the actual calibration coefficient needs to be changed is made dependent on the suggested coefficient as computed from the most recent 250–300 collocations. An obvious drawback of accumulating collocation data over a couple of days is the lagged response of the calibration to rapid changes which may occur due strong water vapor contamination in the beginning of the satellite's life in space.

The vicarious calibration method described here was operationally introduced in Sept. 1987. After the introduction we observed an increase in the calibration coefficient by ~10%. Although the change may partially be real due to contamination and temperature effects, one can estimate that the WV calibration coefficients provided in our quarterly *Calibration Reports*[27] are biased low by at least 5% prior to Sept. 1987, which may be important news to METEOSAT data users in the research community.

The operational application of the vicarious calibration described in this work will be relevant to future METEOSAT satellites at least until 1995, since no basic change of the onboard calibration concept will occur for the satellites scheduled for launch.

A future study will describe the long-term monitoring of the WV calibration over a cycle of at least one year. As a preliminary example Fig. 8 presents a time series over 48 days of α_{WV} for METEOSAT-3, which was launched on 15 June 1988 and made operational on 11 Aug. 1988. The crosses pertain to daily calibrations based on collocation data from the last four days, which here corresponds to averaging over some 200–250 collocations. The solid line depicts the calculated trend. It is observed that the daily suggested coefficients show a day-to-day variability well within 2%. From Julian day 235 (22 Aug. 1988) to day 282 (8 Oct. 1988) α_{WV} increases by more than 6%. The trend is primarily caused by water vapor contamination of the detector (at 90 K) and the cold part of the optical system. The solid squares show the coefficients actually used in the operational software and which are communicated to the user either in the dissemination header of high resolution image data or with the *Quarterly Calibration Reports*.[27]

A further point of interest may be to study the difference in using radiosondes from 1200 and 2400 UT, respectively. A preliminary analysis suggests that the use of day time data leads to calibration coefficients ~1% higher. A simple explanation could be a warm temperature bias in the radiosoundings introduced by solar heating of the instruments. McMillin *et al.*,[28] however, point out that some radiosondes do show substantial errors (0–2 K) due to longwave emission. The effect is highly variable with latitude, season, and cloud condition. Further work may be warranted on that point. For the time being it seems best to use both night and day time data from radiosondes for the vicarious calibration.

I wish to thank Joel Hoffman, Brian Mason, and Volker Gaertner for comments on the manuscript. Thanks are also due to Arno Koch for providing Fig. 8. The cooperation of Olli Turpeinen during the operational implementation of the calibration method is appreciated.

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Annex VIII

Production of High Level CMW from Meteosat Imagery

THE PRODUCTION OF "HIGH" LEVEL C.M.W. FROM METEOSAT IMAGERY.

This note presents the differences between the operational schemes used for deriving high level cloud motion winds (CMW) before ('old') and after ('new') 7 March 1989.

1. Prior to 7 March 1989

1.1 Vector determination

The CMW are determined from infrared images (10.5-12.5μm) using a cross correlation technique over segments of 32x32 IR pixels. Only those segments of the image that have been classified as containing cloud, as a result of a multispectral histogram analysis, are processed; typically 50% of the segments within the 55 degree great circle arc of the sub-satellite point fall into this category. Correlations are performed between two adjacent pairs of half-hourly images and the maximum in each of the two correlation surfaces is determined using a search strategy, which reduces CPU requirements.

The resulting two vectors, V- (as a result of the processing between H-30′ and H), V+ (from H and H+30′), are checked for symmetry and the CMW is computed from the pair (V-, V+).

1.2 Height assignment

The height assignment of a CMW is determined from the mean IR radiance of the cloud cluster that contributes most to the correlation. In the case of multi-layer clouds, if the partial correlation of the individual layers is too low the CMW is not produced.

For semi-transparent clouds a correction is applied to the IR radiance using a relationship between the IR and WV image data (Bowen R. and Saunders R., 1984). The black body temperature equivalent to the measured radiance is converted into a pressure level using the forecast temperature profiles obtained from ECMWF.

1.3 Windowing technique for high level clouds

Since February 1987 a windowing technique has been applied to the derivation of high level CMW ($p < 400$ hPa); this technique has been described by Schmetz and Nuret (1987). The principles of the technique are as follows:

- in the first stage CMW are derived using, for the computation of the correlation surfaces, the whole of the radiometric information (no discrimination of the cloud layers);

- at the second stage, for those CMW attributed to the high level, only the radiances emanating from the high level cloud are retained in the IR image (all other values are set to zero). The windowed radiances are then used to perform a further correlation search starting from the end point of the vector computed in stage one. The aim is to find a better peak in the correlation surface by excluding the influence of radiances from lower level clouds and thus alleviating the problem of different cloud layers moving with different velocities.

2. Since 7 March 1989

2.1 Level classification of cloud tracers

The first major difference in the 'new' scheme is that the attribution of the cloud tracer to a given level (low, medium or high) is determined at stage 1 using the results of the histogram analysis; two cases are distinguished:

- no high level cloud present in a segment;

- high level cloud present in a segment (cloud at other levels may or may not be present).

2.2 Vector determination

In the first case noted above an attempt is made to produce a medium or low level wind. In the second case, irrespective of whether the segment contains only high level clouds or multi-level clouds, an attempt is made to derive a high level CMW. The windowing technique is used immediately after level determination but the starting point for the computation of the correlation coefficients is that suggested by the ECMWF wind forecast. This point indicates the centre of a square in which all the correlation coefficients are computed. The number of correllation coefficients computed between the first pair of images is 35 x 35, the end point of the calculated vector being used as the starting point of the 19 x 19 correlation coefficients calculated between the second pair of images. In the situation where a forecast wind field is not available, the number of correlation coefficients calculated between the first pair of images is increased to 55 x 55, starting at the centre of the concerned segment.

2.3 *Height assignment*

In the 'new' scheme the partial correlation of the individual layers is not performed since the level of the tracer is already known. The corrected (if necessary) mean radiance of the high level tracer used to determine the vector, via the windowing technique, is used directly to assign the pressure level by the same method as for the 'old' scheme.

3. Comparison of the two schemes

The 'new' scheme for deriving high level cloud motion winds (the derivation of CMW at other levels remaining unchanged) was introduced operationally on 7 March 1989. Attached to this report are a number of figures showing the results of comparisons of METEOSAT CMW with radiosonde winds received via the ESOC telecommunication link with RTH Offenbach. They show that the introduction of the 'new' scheme has resulted in high level CMW of at least the same quality to those of the 'old' scheme, indeed on the five months data available there is a clear indication of an improvement in both the vector and speed differences and their respective RMS values. The speed ratio (METEOSAT CMW speed / mean radiosonde speed) also shows a clear indication of an improvement. A further advantage has been an increase in the number of high level winds disseminated, approximately 20% more with the 'new' scheme than with the 'old'.

In conclusion it appears that, based on the first few months of operational service, the 'new' scheme produces winds of at least the same, if not better, quality than the 'old' scheme plus an increase in the overall number of good quality high level CMW.

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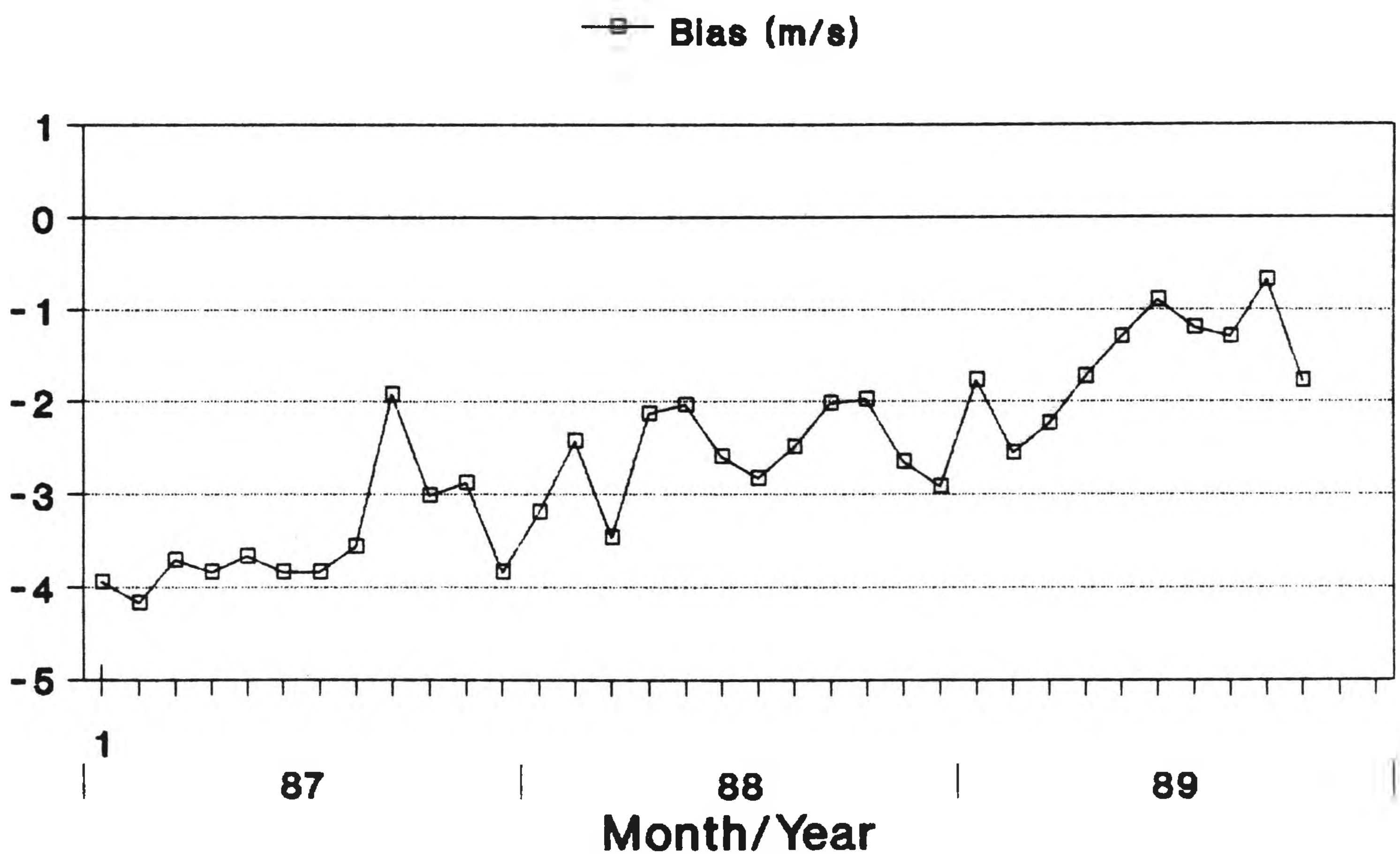
METEOSAT-2/3/4 Met.Products

High Level Cloud Motion Winds



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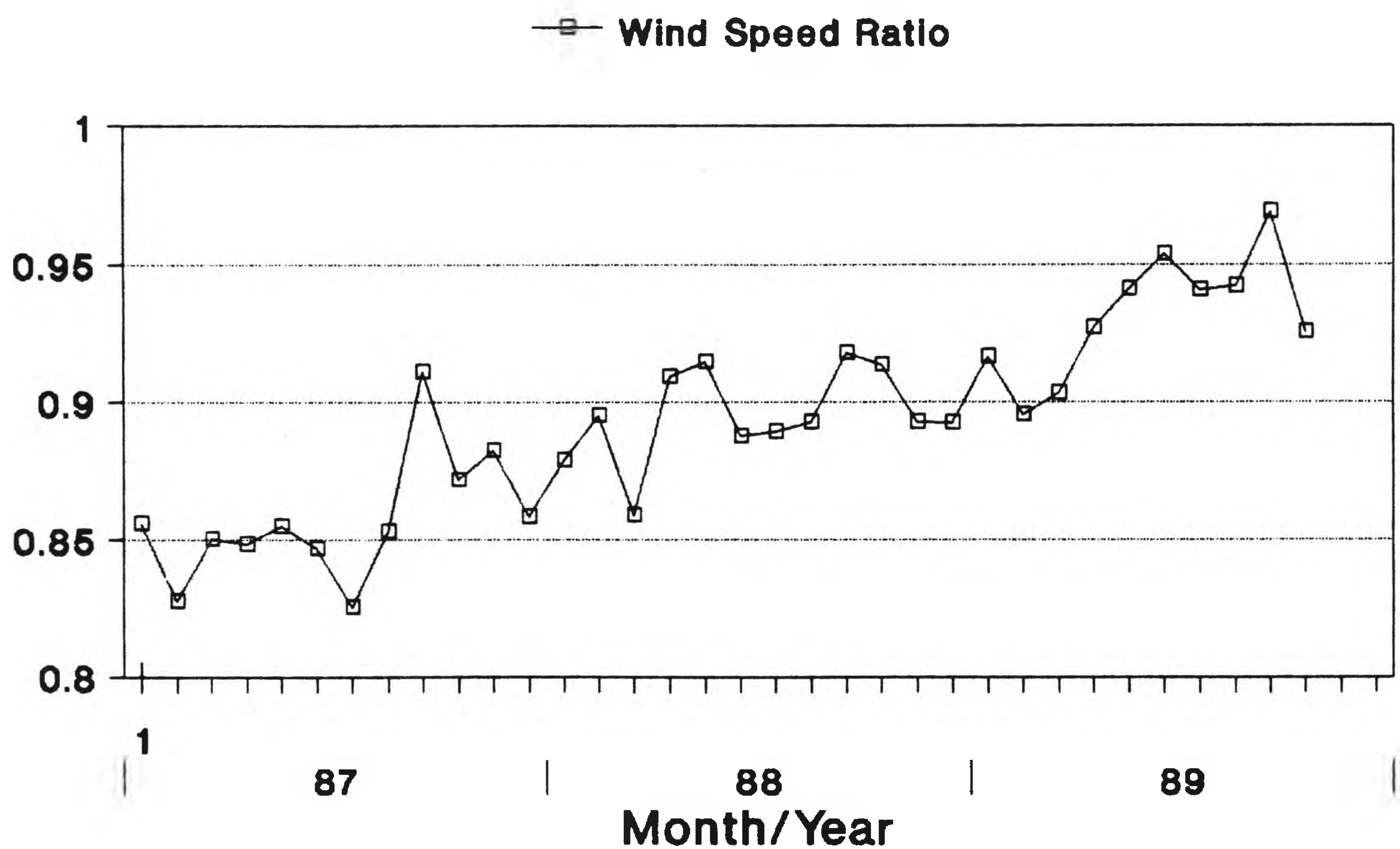
High Level Cloud Motion Winds



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Annex IX

List of Authors of USA Working Papers

List of Authors of USA Working Papers

PAPER #	Author(s)	Agenda Item	Paper Topics
1.	Carl Staton	A.5	Review actions from CGMS 17
2.	Gary Davis	B.5	Status of US Sat Systems*
3.	Ed Bisone	C.1.5	Future Satellite Systems (GOES)
4.	Christopher Cripps	C.2.5	Future Satellite Systems (KLM+)
5.	Carl Staton	C.3	Satellite Continuity*
6.	Carl Staton	D.1	WeatherWatch International
7.	Carl Staton	E.1	Status of IDCS
8.	James Neilon	E.3	ASDAR Update
9.	Carl Staton	F.1.2	WEFAX Schedules & Common Header
10.	Warren Dorsey	F.1.3	DCP Data/Update on DAPS
11.	Carl Staton	F.1.4	Digital WEFAX
12.	Curtis Holland	H.1	Comparison of Satellite Winds
13.	Gene Legg	H.1	Increased Domain for Extraction
14.	Paul Menzel	H.1	Quality of Sat Winds NESDIS
15.	Al Thomasell	H.1	Plans for Winds Quality Control
16.	Phil Arkin	H.3	Precipitation and Cloud Cover
17.	Dane Clark	H.3	VAS Products
18.	Paul Julian	I	New Products (GOES+)
19.	Pat Mulligan	I	New Products (NOAA-KLM)
20.	Vollmers/Cripps	L	GOES Search & Rescue Program
21.	Joe Allen	L	Satellite Anomalies
22.	Christopher Cripps	L	Winds Profiler Interference

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Annex X

Parameterisation of regions of deep convection, and improvement of the estimation of moisture data from satellite cloud soundings

CGMS-XVIII WP-17
Prepared by Japan
Agenda Item: J

Parameterisation of Regions of Deep Convection

Summary and Purpose of the Document

Japan reviewed ACTION 17.19 of CGMS-XVII concerning the information relating to areas of deep convection. JMA's reply on this subject already sent to the CGMS secretariat is shown in this document.

Action Proposed

CGMS is asked to discuss what type of information relating areas of deep convection is required by the data assimilation community.

CGMS-XVIII WP-17
Prepared by Japan
Agenda Item: J

Parameterisation of regions of deep convection

JMA requires three parameters as information relating to areas of deep convection and desires all CGMS Members to exchange them through GTS for the achievement of global coverage.

(1) Total cloud amount,

(2) Mean brightness temperature for cloud covered area, and

(3) Standard deviation of brightness temperature for cloud covered area,

in a grid box whose size is 1°x1°or 0.5°x0.5° latitude/longitude.

JMA developed a procedure to estimate three-dimensional distribution of water vapor using these parameters derived from GMS images. Its general conception is shown in Fig.1. The procedure has been used in operational data assimilation schemes of the JMA's numerical prediction model.

An impact study for the procedure shows that these parameters are effective to analyze moisture field in convective areas and to improve an accuracy of the prediction model, especially in the tropics.(see Attachment)

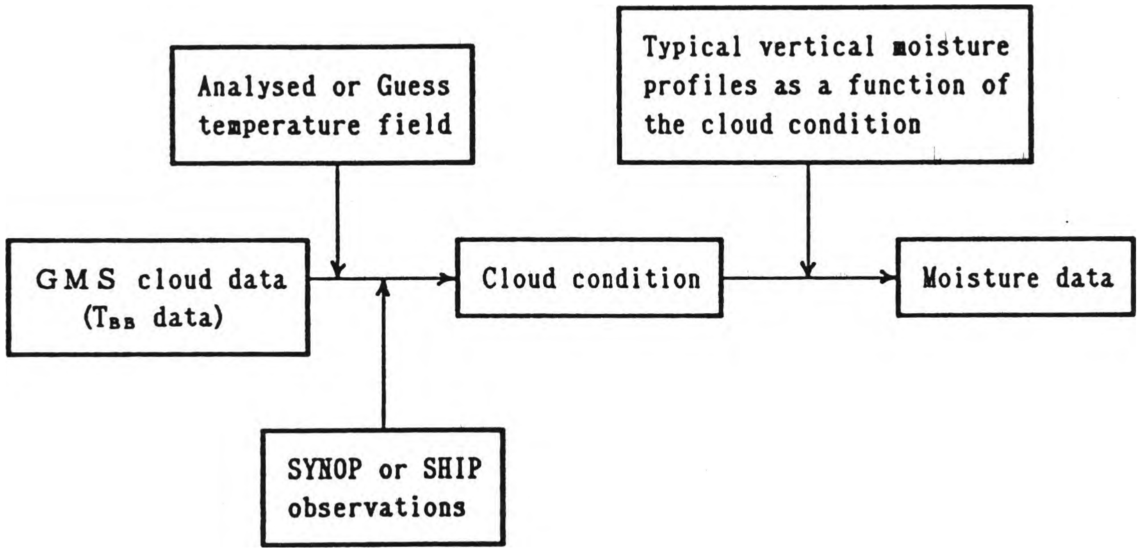

Fig.1 Using GMS Cloud data and SYNOP observations, cloud condition can be determined. Moisture data are estimated using the typical vertical moisture profile data set which have been established by a statistical technique.

CGMS-XVIII WP-17
Attachment
Prepared by Japan
Agenda Item: J

JMA/NPD TECHNICAL REPORT No.16

IMPROVEMENT OF THE ESTIMATION METHOD OF MOISTURE DATA FROM SATELLITE CLOUD SOUNDINGS

by

Atsushi Baba

July 1987

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CONTENTS

Abstract

The statistical estimation scheme of moisture data by satellite cloud soundings was improved and the influence of the improvement on moisture analyses and numerical weather predictions was studied.

The satellite cloud moisture data have been objectively estimated by GMS cloud data and utilized in routine moisture analyses at JMA. The GMS cloud data offer information about the cloud conditions, such as cloud amount and cloud top equivalent black body temperatures. We classified the cloud conditions by the GMS cloud data. For each cloud condition, we statistically determined typical moisture profiles vertical using a large number of TEMP data observed under the same cloud condition. Thus, if we get the GMS cloud data at a point, we can objectively estimate the upper moisture data as a function of the cloud condition defined by the GMS cloud data.

The improvement on this estimation scheme was mainly made in the following two points: (1) classification of the cloud conditions and (2) construction of typical moisture profiles for cloud conditions. We used synop observations in addition to the GMS cloud data to classify the cloud condition. We also divide the cloud conditions into two groups according to the latitude of the data; the one was tropical group (23.5°N - 23.5°S) and the other was subtropical group (50°N - 23.5°N, 23.5°S - 50°S).

The vertically smoothed TEMP data were used to give the typical moisture profiles for the cloud conditions. To smooth TEMP data, we chose "typical" profiles(close to modal) rather than the simple "mean" profiles.

Moisture analyses with the new satellite cloud moisture data give more realistic moisture fields than those the conventional satellite cloud moisture data, especially in cloud regions.

The impacts of initial moisture field analyses with the new satellite cloud moisture data on the numerical weather prediction were investigated using a limited area grid point model(12L-FLM). Some improvements were found in the forecasts. In paticular rainfall performance was drastically improved.

1 Introduction

Water vapor is one of the most important atmospheric parameters for numerical weather prediction (NWP) models. In order to obtain results by NWP models, especially for rainfall forecasts, it is essential to use accurate initial moisture fields. Therefore, analyses of moisture field should be performed with special attention.

In this respect, use of observations with high accuracy is quite important. At present situation, radiosonde observations are only reliable for the upper level moisture analysis. However, radiosonde observation network is too sparse, especially over the ocean, to perform accurate moisture analyses with considerable resolutions in horizontal and vertical.

To provide more information of upper level moisture, retrieval methods of water vapor profiles from satellite sounding have been attempted(e.g. Smith and Howell, 1971; Hayden et al., 1981; Lipton et al., 1986; etc.). The retrieved water vapour fields showed a substantial accuracy under cloud-free condition, but fine vertical structure could not be retrieved; the retrieval methods cannot determine the moisture field in cloud regions.

Estimations from other types of observations have also been attempted. For example, Chisholm et al.(1968) investigated the relationship between surface synoptic observations and the colocated TEMP data and developed a diagnostic approach to estimate humidity at standard pressure levels (850mb, 700mb, 500mb, 400mb) from surface observations. Jonas (1976) demonstrated that the upper moisture data estimated from surface observations have considerable availability for the upper level humidity analysis.

The cloud images observed by meteorological satellites have also been used to estimate water vapor fields (Thompson and West(1967), Smigielski and Mace(1970), Walcott and Warner(1981), Mills(1983) etc.). Wolcott and Warner (1981) applied satellite cloud data to moisture analysis with the additional information of the present weather observations as follows ; if precipitaion is observed, relative humidity is assumed to be 100% from the surface to the cloud top level. If not, it is assumed to be 100% only at the cloud top level. They showed that these data allowed a NWP model to improve the forecast of rainfall rates.

At Japan Meteorological Agency(JMA), using cloud data obtained by GMS (GMS cloud data), vertical moisture profiles have been estimated and used in the routine moisture analysis. The GMS cloud data, which are compiled from equivalent black body temperature(T_{BB}) retrieved from infrared radiation observed by GMS at Meteorological Satellite Center(MSC), give the information about cloud condition in every 1°x1° latitude/longitude grid box over the area 50°N-50°S, 90°E-170°W. Using statistical relationships derived from the comparison between the GMS cloud data and actual moisture fields observed by other direct methods such as radiosonde data, we determined the vertical profile of dew point depression(T-TD) as a function of the GMS cloud data. Thus with the GMS cloud data, we can automatically (objectively) estimate a vertical moisture profile for each 1°x1° grid box and use it in the routine analysis of moisture. We hereafter call the estimated moisture profile by GMS cloud data as "satellite cloud moisture data".

The satellite cloud moisture data has improved moisture analyses at JMA. However, it was found that the moistures were insufficient in cloud region when the satellite cloud moisture data were used in analyses. This error was attributed to a problem in the estimation method of moisture profile from GMS cloud data. Therefore, to improve the moisture analyses, we revised the estimation method. Revisions were mainly made about the following four points ; (1) the improvement of the method to determine cloud conditions from GMS cloud data, (2) the improvement of the prescribed vertical moisture (T-TD) profiles for each cloud condition, (3) the utilization of synoptic observations, and (4) the separation of the estimation method for the tropics and the subtropics.

The moisture analyses with the new satellite cloud moisture data give more realistic moisture fields than the old analyses, especially in cloud regions.

2 Observations available to estimate cloud condition

(a) GMS cloud data

We receive the cloud data derived from the T_{BB} observed by GMS from MSC twice a day (0000UTC,1200UTC). We call the data as "GMS cloud data". It consists of several parameters which represent the cloud characteristics in each 1°x1° latitude/longitude grid box over the area 50°N-50°S, 90°E-170°W.

Details about the GMS T_{BB} observation system is found in Meteorological Satellite Center(1980).

The contents of the GMS cloud data are listed in table 1. They are cloud amount at each level, mean T_{BB} at cloud top, standard deviation of T_{BB} in a 1°x1° box, and sea surface temperature. They are calculated from the observations of about 400 pixels in a 1°x1° grid box. The observed T_{BB} of a pixel corresponds to the cloud top temperature or surface temperature. Whether the T_{BB} is at the cloud top or at the surface is judged by comparing it with a reference surface temperature at the observing point. Sea surface temperature is used over the ocean, and 1000mb temperature of climatology (GMSSA - GMS Standard Atmosphere) is used over the land. The T_{BB} judged as that at the cloud top is converted to the cloud top level pressure using the the vertical temperature profile of GMSSA. The cloud amount in a level is the ratio of the number of pixels whose T_{BB} specify the cloud top in the same level to the total number of pixels in the grid box. Therefore, the cloud amount is not the net cloud amount in the level. It does not include low level clouds covered by upper level clouds. The mean T_{BB} at cloud top is calculated using observed T_{BB} only in cloud area. On the other hand, a standard deviation of T_{BB} is calculated using all T_{BB} data in a grid box. Therefore, it has a meaning as a parameter of cloud only when the total cloud amount is 100%.

Figure 1-a shows cloud distribution at 1200UTC 24, June 1986, represented by the total cloud amounts of the GMS cloud data. The total cloud amount of a grid box is the sum of cloud amounts at all levels. Figure 1-b also shows cloud distribution at the same time represented by the mean T_{BB} at cloud top. The contours are drawn for regions where the T_{BB} is lower than -5°C. Cloud areas shown in the two figures coincide well with each other but there are cloud regions found in figure 1-a but not in figure 1-b. These areas are considered to be covered mainly with low level clouds.

Figure 2 shows infrared satellite photograph by GMS-3 at the same time. One can find that most of the cloud regions shown in figure 1-a also exist in figure 2. However, there are no cloud in eastern Australia in figure 2 where they are cloud coverages in figure 1-a. Figure 3 shows Synop observations around Australia at the same time. It indicates that there are no clouds in eastern Australia. Therefore, there is a problem in the cloud amount data calculated by the GMS cloud data for low level clouds.

Kubota et al.(1980) showed that the cloud amounts over the land were tend to be overestimated by the method of MSC in judgement of cloud tops from the GMS cloud data. As mentioned before, whether the observed T_{BB} is at cloud top or at land surface is judged by comparing the T_{BB} with climatological 1000mb temperature of GMSSA. If the surface temperature in the land area is lower than the 1000mb temperature of GMSSA, it is judged that the observed T_{BB} is at cloud top but not at land surface. This error happens frequently over the land in winter season. The same error is also found in the Tibetan platean due to its high elevation. Therefore, to obtain satellite moisture data, we must take a care of the accuracy of the cloud amounts from the GMS cloud data calculated by MSC, especialy over the land area.

We use 3 parameters of the GMS cloud data to classify the cloud conditions: the total cloud amount in a grid box, the mean T_{BB} at cloud top, and the standard deviation of the T_{BB}. The total cloud amount is used to specify the integrated moisture condition in the grid box; If it is 0%, the moisture condition is thought to be dry, or if it is 100%, it should be moist. The mean T_{BB} at cloud top is used as a parameter to give vertical structure of the moisture in the grid box. From mean T_{BB} at cloud top, we compared the mean level of cloud top using TEMP data and/or guess temperature field. We do not use GMSSA. The standard deviation of the T_{BB} has an information about cloud type in the grid box; If it is large, we regard that the main cloud type is cumulus and that the transition layer from moist (cloud) to dry areas is thick. If it is small, the cloud type is regarded as stratus; the transition layer is thin.

In the conventional estimation method of satellite cloud moisture data, on these 3 parameters have been used in the classification of the cloud conditions. The new method uses the Synop obervations as well as GMS cloud data, which will be discussed below.

(b) Synop observations

The GMS cloud data gives the information surveyed above clouds, so that it has essentially no clue to estimate the moisture conditions in the layers below the top of the cloud. On the other hand, Synop observations offer cloud or moisture information observed from bottoms of clouds. Therefore, if we use both Synop observations and the GMS cloud data, a better estimation will be obtained about the vertical profiles of moisture.

We introduce 3 terms in the Synop observations for the classification of cloud conditions, i.e., present weather(ww), height above ground of the base of the lowest cloud seen(h), and amount of all low clouds(Nh). When the present weather is precipitating, it is estimated to be moist from the cloud top to the surface. If no precipitation is observed and there are no low clouds, it is estimated to be dry in the low levels, even if there are high level cloud covers.

3 Procedure to obtain moisture vertical profiles in the new satellite cloud moisture data.

(a) Classification of cloud conditions

At each 1°x1° grid box, the cloud conditions are classified into 141 categories using 5 main elements and 2 supplementary elements(sub-elements) in the GMS cloud data and Synop observations. The main elements are total cloud amount, standard deviation of T_{BB}, mean cloud top level from the GMS cloud data, present weather(ww) by synop observation, and latitude of the grid box. The sub-elements are height above ground of the base of the lowest cloud seen(h) and amount of all low clouds(Nh) in Synop observation. They are shown in table 2.

We divided the total cloud amount into 6 classes, i.e., 0%,1%-10%, 10%-50%, 50%-80%, 80%-99%, and 100%. When it is 100%, the standard deviation of T_{BB} is used for the classification. We divided it into 2 classes whether it is less than 4K or greater equal 4K. As mentioned in section 2, the mean T_{BB} at cloud top is converted to the mean level of the cloud top. It is separated into 4 classes: higher than 450mb, 450mb-660mb, 660mb-810mb, and lower than 810mb. However, if the total cloud amount in the grid box is less than 10%, the mean cloud top level is not used in the classification.

The present weather(ww) has 3 classes: Wet (precipitation: ww=13-29, 38-99), Dry (no precipitation: ww=00-12,30-37), and Free(no observation). When the present weather is not observed, it is classify into "Free". It includes all case of present weather, i.e. Wet and Dry cases. The height above ground of the base of the lowest cloud seen(h) and amount of all the low cloud(Nh) are used only to check weather it is dry at the low levels. If h=8 or 9, and Nh=0 or 1, it assumed that the low level atmosphere is dry. These sub-elements(h,Nh) are used only in necessary cases.

Because humidity in the tropical region is generally higher than that in the extratropics, cloud conditions are divided depending on the latitude of the grid box into the tropical region (Tropics 23.5°N-23.5°S) and the other regions (Subtropics 50°N-23.5°N, 23.5°S-50°S).

We define the cloud conditions according to the combinations of these elements. Details of the combinations of the elements for each cloud condition are shown in table 3. The numbers of cloud conditions in the tropical region are from 1 to 66. Those in the subtropical region are from 67 to 141. For cloud condition numbers from 67 to 132, the elements of classification are the same as those from 1 to 66, respectively, except for the location. The cloud conditions defined with the sub-elements are numbered from 133 to 141.

(b) Smoothing of vertical profiles of radiosonde T-TD

For construction of typical vertical profile of T-TD corresponding to each cloud condition, we use the TEMP data which are observed under the same cloud condition. We use not only the standard level data but also the significant level data. The observed T-TD profiles often have fine structures with thin layers of high or low humidity. However, these small vertical features are generally of secondary concern in the NWP models and the present satellite moisture data does not have accuracy to evaluate such small structures. Therefore, we smooth the observed TEMP T-TD profiles before comparing them with the cloud conditions discussed above. Figure 4 shows one of examples of an observed T-TD profile (thin line) and the smoothed one (thick line). The smoothing process is as follows:

(1) The observed T-TD is converted into relative humidity and the vertical profile of relative humidity is constructed.

(2) Reference levels P_k are set at every 50mb level from 1000mb to 300mb. For each level, the observed vertical profile of relative humidity is integrated

from P_k-50mb to P_k+50mb, and the mean humidity at this level is obtained. The mean humidity is regarded as the smoothed value.

(3) The vertical prfile of relative humidity is reconstructed with the smoothed values.

(4) The profile of relative humidity is converted to that of the T-TD.

(c) Determination of the typical T-TD profile for each cloud condition

Using the smoothed TEMP data, typical vertical profiles of T-TD are determined statistically for each cloud conditions. In this process, we have to take care of the following points; (1) The accuracy of the GMS cloud data is not satisfactory over the land. As mentioned in section 2-(a), the cloud amount over the land is tend to be overestimated. Therefore, satellite cloud moisture data is performed only over the ocean area and the TEMP data observed at stations on islands or ships over the ocean are only used. (2) If there is an inversion layer, the mean T_{BB} at cloud top has sometimes two or more corresponding levels; in such a case, the highest one is selected as the level of the cloud top.

TEMP data used for the statistics were accumulated from February 1984 to June 1986. The accumulated TEMP data were sorted according to the cloud conditions. Using the sorted data the most approprate estimate of T-TD vertical profiles for esch cloud condition was determined.

Figure 5 shows one of examples of the histgram of the smoothed TEMP T-TD values at 850mb level for the cloud condition No.56 (total cloud amount is 80%-99%, mean cloud top level from 450mb to 660mb, present weather Free, and the location in tropics). In the conventional satellite cloud moisture data, the mean value of the histgram of the sorted TEMP data was used as the value of the typical T-TD profile of a cloud condition. However, in the new satellite moisture data, not only the mean value but also the mode are used to specify the typical T-TD value at refernce levels. This is because that the mean value does not necessarily mean the representative moisture value for the cloud condition. In the example shown in figure 5, the mean of the data is 3.2K, but is not appropreate for the representive value of data. We should select the mode 1.5K.

After specifying the typical value at every 50mb level using the smoothed

TEMP T-TD, the typical vertical profiles are produced.

We will show an example how the T-TD profiles produced for the cloud condition No.56.

We accumulated TEMP data which were observed under the same cloud condition. The total number of the data was 672. They were smoothed vertically through the process mentiond in section 3(b). From all smoothed profiles, we made a dataset of T-TD values at every 50mb level from 1000mb to 400mb. Figure 6 shows the histgrams of the datasets at all levels.

We performed data quality control on the datasets. We eliminated exceptional data if they were out of the 1.8 times of the standard deviation from the average. We repeated this quality control process until there were no data out of the specified range. Through the process, exceptional data were eliminated and there remained only typical data in the new datasets. The eliminated data were about 10%-20% of the original data as shown in table 4.

With the new datasets, the mean value and the "peak" value were used to define the typical T-TD value at each level instead of the mode. The "peak" value was defined as shown in figure 7.

The process above is illustrated in table 5 and the final profile is shown in figure 8. The "peak" values were used as the typical T-TD values at the levels from 1000mb to 650mb, the mean value for 400mb level. At 600mb and 500mb levels, the values are defined by averaging the mean and "peak" value with the weights of 2 and 1, respectively, at 600mb and 1 and 2 at 500mb level.

Figures 9-(a) through 9-(g) show the final profiles for all cloud conditions.

In objective analysis of the moisture, we also need the information on the errors of satellite cloud moisture data which are equivalent to the observation errors of SYNOP and TEMP data. The root mean square error for each final T-TD value from the corresponding dataset after quality control was used as the observation error of the satellite moisture data. They were about 1.5K - 2.5K at 850mb, 2.0K - 5.5K at 700mb, 3.0K - 8.0K at 500mb, and 4.0K - 8.0K at 400mb. The observation errors of TEMP data were fixed to be 1.0K in moisture analyses.

4 Estimation of the satellite cloud moisture data in moisture analyses

The satellite cloud moisture data are estimated and utilized in moisture analyses in the following process.

(1) From the GMS cloud data, total cloud amount, mean cloud top level, and standard deviation of T_{BB} are computed at each grid box. The mean cloud top level is determined by the mean T_{BB} at cloud top and the vertical temperature profiles of the guess fields in the analysis.

(2) Present weather (ww), height above ground of the base of the lowest cloud seen(h), and amount of all the low cloud(Nh) in SYNOP and SHIP data are examined at every grid box. If there is at least one station observing precipitation in the 1°x1° grid box, the weather parameter is regarded as Wet (precipitation). If there are no stations which observe precipitaion, it is Dry (no precipitation). If all observing stations report missing data or there are no SYNOP and SHIP data in the grid box, it is Free. The sub-elements(h,Nh) are considered in the Dry situation to check the moisture condition in the low level atmosphere as mentioned in section 3-(a).

(3) The latitude of the grid box is checked. If it is between 23.5°N and 23.5°S, the location parameter is Tropics, if not, it is Subtropics.

(4) The cloud condition is then determined by the combination of the parameters from Table 3-1 and 3-2, and the corresponding T-TD profile is selected (Figure 9-(a) to (g)).

(5) The data at the standard pressure levels of the selected profile are utilized as T-TD data in the moisture analyses at the upper levels. The RMS errors of the satellite cloud moisture data are also used as the observation errors in the analyses.

5 Moisture analysis including the new satellite cloud moisture data

We investigated the results of the moisture analyses including the new satellite cloud moisture data at upper 4 standard levels(850mb, 700mb, 500mb, 400mb) at the 2.5° latitude-longitude grid system. The analysis scheme is the same as that used in the JMA data assimulation system (Kashiwagi, 1984). It is based on a two-dimentional optimum interpolation method whose background field is provided by the 12 hour forecast of L12-T42 global spectral forecast model (Kanamitsu et al. 1983).

The map time 1200UTC 24 June 1986 was investigated. The infrared satellite photograph by GMS 3 was already shown in Figure 2. Figure 10 shows the surface weather chart around Japan. A stationary front (Bai-u front) extended from the north-western Pacific Ocean to China through the Japan islands see cloud band in Figure 2. A Tropical Storm (NANCY-TS8605) was at 30°N,123°E in the East China Sea. The intertropical convergence zone (ITCZ) was between 15°N and the equater. A clear region of the subtropical high was between the stationary frontal zone (Bai-u front) and the ITCZ. The trade-wind cumulus clouds spreaded over the eastern Indian Ocean and the shallow cumulus clouds whose tops were lower than 3000m also spreaded near the eastern coast of the Australia. (They were not clear in the IR satellite photograph of Figure 2.)

Because the resolution of the analysis is 2.5° latitude-longitude, if the satellite cloud moisture data are estimated at all 1°x1° grid boxs over the ocean, there are too many data to perform the analysis. Therefore, we basically estimate satellite moisture data at every 2°x2° latitude-longitude interval. In addition to them, the satellite cloud moisture data were also estimated at a grid box even if the grid box is not the 2°x2° interval, when any SYNOP or SHIP observations were reported at the grid box. This was because that T-TD profiles determined with the SYNOP observations have much reliability than those determined only with the GMS cloud data.

Figure 11 shows the distribution of the satellite cloud moisture data used in the analyses. The numbers of the estimated satellite cloud moisture data for each cloud condition are shown in table 6. The total number were 1054 in the tropical region and 987 in the subtropical region. The numbers of those used SYNOP obserbvations are 113 and 122, respectively.

The moisture analyses including the new satellite cloud moisture data are shown in figure 12. We will call the new analyses the Test analyses. Because the observation errors of satellite cloud moisture data are greater than those of TEMP data, the effects of the TEMP data dominate on the analysed field near the stations. However, the moisture analyses are usually performed under the effects of the satellite moisture data over the ocean, because the TEMP data are very sparce there. The Bai-u front and the ITCZ were well expressed at all analyses levels. The areas of the Trade-wind cumulus clouds in the eastern Indian Ocean and of the shallow cumulus clouds near the eastern-west Australia were expressed as moist areas at 850mb level but dry areas at 500mb and 400mb levels. The analyses also expressed the clear region of the subtropical high as a dry area at all levels.

To investigate the effects of the new satellite cloud moisture data on moisture analyses, we performed the moisture analyses with the conventional satellite cloud moisture data. We will call the analysis the Control analyses. The satellite cloud moisture data were also estimated at every 2°x2° latitude-longitude interval over the ocean in the northern hemisphere. Except for the satellite cloud moisture data, the conditions of the Control analysis were identical with the Test analyses.

As the old satellite cloud moisture data were not estimated routinely in the southern hemisphere, the effects of the satellite cloud moisture data on the moisture analysis were apparent by comparing the Test analysis with the Control one in the southern hemisphere. Figure 13 shows the two moisture analyses at 500mb in the southern hemisphere. Around Indonesia, it was dry in the Test analysis but moist in the Control analysis. Considering the satellite infrared photograph (see Figure 2), it would be better to analyse dry there. The similar improvement can be also seen in other areas such as around 10°S,170°E, and 40°S,120°E. One can confirm that the satellite cloud moisture data is useful to improve the moisture analyses.

The comparison in the northern hemisphere shows the differences of the effects on the moisture analyses between the new satellite cloud moisture data and the conventional ones. Figure 14 shows the two moisture analyses in the northern hemisphere. The results of Test analysis were generally moister than the Control one, especially in the cloud areas. Considering the infrared satellite photograph (Figure 2), it seems that the moisture in the cloud areas was insufficient by the Control analysis. This difference is derived from the difference in constructing the typical moisture profiles. The profiles of the conventional satellite cloud moisture data were determined by the simple mean of the histogram of the accumulated TEMP data, while those of the new satellite cloud moisture data were determined by mainly the "peak" values of accumulated data(see section 3-(c)). The new satellite mosture data gives a smaller T-TD in the cloud areas than the conventional one. It is the main advantage of the new satellite cloud moisture data, although, it involve a risk that the analyses fields happen to be too moist.

To verify the satellite cloud moisture data, we compared the estimated satellite cloud moisture data with the colocated TEMP data at the stations on the Pacific Ocean (91 group of SYNOP stations) during November 1986(Table 7). The guess data also compared with the TEMP data. In Table 7 the "bias" is the mean deviation of the satellite cloud moisture data (or guess data) from the corresponding TEMP data. If it is lower than 0.0, the data has a tendency to be moister than the observed TEMP data. The results shows that the satellite cloud moisture data were moister than the TEMP data at all levels. This is due to the use of the "peak" values for the typical T-TD profiles.

6 An impact test of the new satellite cloud moisture data on numerical weather prediction

We studied the influence of the new satellite cloud moisture data on numerical weather prediction using operational 12-level Fine Mesh Limited area model(12-FLM) at JMA. The description of the model is found in Electronic Computation Center(1983).

Two experiments were run with different initial moisture fields. The one used the analysis with the new satellite cloud moisture data which will be refered to as "Test run". The other utilized analysis with the conventional satellite cloud moisture data, which will be refered to as "Control run". The runs differ only for the initial moisture fields.

The analyses were performed on the 60°N stereographic map projection system whose grid length is 254km at 60°N. The number of grid points is 56x48. The first guess fields were 12 hour forecasts of the 12L-T42 northern hemisphere spectral model.

The initial state chosen was 0000UTC 26 August, 1986. Figure 15 shows infrared satellite photograph by GMS 3 and Figure 16-a shows the sea surface weather chart. A tropical storm (Vera - TS8613) was at 26°N,127°E and 3 Tropical Depressions (TD) were observed, i.e., 1000mb at 19°N,115°E, 1004mb at 21°N,149°E and 1008mb at 20°N,159°E. The clear region of the Subtropical High was over 25°N-40°N, 135°E-180°E.

Figure 17 shows the T-TD analyses at the initial state. Comparing the analyses of the Test and Control runs with the IR image of satellite (figure 16), it is found that the analyses of the Test run is better than those of the Control run. It is too dry in the cloud areas in the Control run.

We compared the two forecasts in terms of accumulated precipitation(RR) during 12 hour forecast period and sea level pressure(PS). Figure 19 shows the forecast results. The test run predicted more amount and wider areas of precipitations than the Control run. For example, during first 12 hour forecast, precipitations were predicted in the South China Sea(19°N,112°E) and the western Sea of Japan(38°N,131°E) in the Test run, but not in the Control run. With respect to the precipitation accompanied by TS8613, the precipitation area in the Test run was broader than that in the Control run. The maximum value of the precipitation area in the Test run was also greater than that in the Control run. The formar was 14mm/6hour and the latter was 6mm/6hour.

To verify the predicted precipitations, we estimated the real precipitatons using SYNOP and SHIP observations(Figure 19). Comparing Figure 18 with Figure 19, we can recognize that the predicted precipitations in the Test run were much closer to the observations than those in the Control run. For the first 12 hours, there observed precipitations in the South China Sea and weastern Sea of Japan(Figure 19(top)), which were predicted by the Test run but not by the Control run. A severe rainfall was observed in the middle Korean Peninsula for both the second and third 12 hour periods. For the second 12 hour period, its maximum was 61mm/6hour. The Test run predicted this rainfall with stronger intensity than the Control run. The maximum precipitation was 16mm/6hour in the Test run during the second 12 hour period. Although the maximum value was smaller than that of the observations, its position was well predicted. In the control run, the maximum was 6mm/6hour, which was smaller than that of the test run and the position was on the Yellow Sea.

A precipitation continued through the whole forecasting periods around at 25°N,158°E in the Test run. However, because no SYNOP or SHIP observations were obtained in the area, one could not recognize it in Figure 19. To estimate the precipitations over the ocean we use the cloud data obtained by meteorological satellite. Figure 20 shows the cloud distributions represented by the observed T_{BB} at cloud top, during 0000UTC 26 August and 1200UTC 26. The lower the cloud top temperature is, the greater the probability of precipitations is expected under the cloud area. Figure 20 indicates clealy the precipitation around at 25°N,158°E.

The predicted Ps was also different between the two runs(Figure 18). At 36 hour forecast the central pressure of the typhoon TS8613 was lower in the Test run than that in the Control run. The position of the typhoon center in the Control run was a little worth to that in the Test run. The synoptic observation (Figure 16-b) shows the central pressure was 972mb and its location was at 31°N,125°E. The forecast of the Test run was closer to the observation in the intencity and location than that of the Control run. The forecasts of a low at 45°N,165°E and of the Subtropical high represented by the 1012mb contour near Japan Islands also showed the better skill of the test run.

We could conclude that the forecast performance apparently improved by the use of the initial moisture fields analysed with the new satellite cloud moisture data.

7 Summary and remarks

Using predetermined statistical relationship between vertical profiles of moisture and the GMS cloud data, the satellite cloud moisture data are routinely estimated from the GMS cloud data objectively and used in thr routine analyses. The GMS cloud data offer information about cloud conditions, such as the cloud amount or cloud top temperatures. We classified the cloud conditions into different types. For every cloud condition, a typical moisture profile was determined statistically by collecting a large number of the TEMP data observed under the same cloud condition. From these relationships between cloud types and typical moisture profiles, if a GMS cloud data is obtained, we can objectively estimate the upper moisture data.

We revised the conventional estimation method of the satellite cloud moisture data, mainly in the following two points: (1) improvement of the classification of the cloud conditions and (2) improvements of the construction of typical moisture profiles for the cloud conditions.

In the classification process, we used SYNOP observations in addition to the GMS cloud data. The GMS cloud data survey clouds above them, while the SYNOP observations offer the cloud informations observed from below. By using two data, one can increase the reliability of the classification of the cloud conditions. We also divide the cloud conditions into two groups according to the latitude of the data; the one is tropical group (23.5°N - 23.5°S) and the other is subtropical group (50°N - 23.5°N, 23.5°S - 50°S). By the division, the satellite cloud moisture data can distinguish the relatively dry atmosphere in the middle latitudes to the moist tropical atmosphere. Combinations of the elements of the GMS cloud data were also revised to give more reasonable classification. The total number of cloud conditions are 141.

In the determination of the typical moisture profiles, the TEMP data for every cloud condition were accumulated as many as possible and the moisture profiles of the accumulated TEMP data were smoothed. Using them, the most suitable moisture profiles are defined for all cloud condition. The "typical" profiles are chosen rather than the simple "mean" of the TEMP profiles. This makes the estimated satellite cloud moisture data more representative of the moisture situations corresponding to each cloud condition than the conventional satellite cloud moisture data.

The moisture analyses with the new satellite cloud moisture data were performed and compared with those with the conventional satellite cloud moisture data. The new ones contribute to the more accurate analyses of the moisture fields than the conventional ones, especially in cloud regions.

The impacts of the analyses with the new satellite cloud moisture data on the numerical weather prediction were investigated by a limited area model (12L-FLM). Rainfall performance was improved drastically; precipitations observed by SYNOP data were predicted well in the Test run(with new satellite cloud moisture data), but not in the Control run(with conventional satellite cloud moisture data). Some improvements were also seen in predicted surface pressure pattern in the Test run.

The satellite cloud moisture data are not estimate over the land. It is because that there are relatively enough number of TEMP data and that the accuracy of the GMS cloud data are not satisfactory over the land. However, there are data sparse areas even over the land. For example, as shown in Figure 11, only few TEMP data stations are found inland of the Australia. We should estimate the satellite moisture data in such areas to increase the information about the moisture.

The problem about the accuracy of the GMS cloud data over the land happens for low level clouds. However, the reliability of the data for observed high level clouds is satisfactory. Therefore, for the next step to improve the satellite cloud moisture data, we must investigate whether the observation of high clouds by the GMS cloud data can be used to estimate the moisture over the land.

The satellite cloud moisture data are quite useful to moisture analyses and give a good impact on numerical weather predictions. At JMA, they are used in the routine global analysis-forecast system. We estimate them only over the ocean in 50°N-50°S, 90°E-170°W. If we can get similar data from other satellites, usefulness of the estimation can be increased. We hope that not only the geostationaly satellites(GOES, METEOSAT, INSAT) but also the orbital satellites offer similar data so that the satellite cloud moisture data can be estimated over the whole globe scale.

Acknowledgements

This work originated from satellite cloud moisture data estimation system at JMA established by S. Isa. The auther is grateful to staff member of Numerical Prediction Division of JMA for many discussions and helpful comments, particulary K. kashiwagi provided many stimulations throughout this work. The auther also thank H. Nakamura and T. Kudo for their careful reading of the first draft of manuscript and many suggestions for improvements.

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Tables

Figures

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Figure 9-c The same as Figure 9-a but cloud conditions No.45-No.66 and present weather is Free.

Figure 9-d The same as Figure 9-a but cloud conditions No.67-No.88 and present weather is Wet and location is subtropics.

Figure 9-e The same as Figure 9-a but cloud conditions No.89-No.110 and cloud condition is Dry.

Figure 9-f The same as Figure 9-a but cloud conditions No.111-No.132 and present weather is Free.

Figure 9-g As Figure 9-a but cloud conditions No.133-No.141 but present weather is Dry and sub-elements(h,Nh) are also used.

Figure 10 Surface weather chart at 1200UTC 24 June 1986.

Figure 11 Data distribution of the moisture analyses at 1200UTC 24 June 1986. The symbol "*" denotes TEMP data. The symbol "+" and "-" denotes estimated satellite cloud moisture data. The former "+" is determined using synoptic observations in addition to the GMS cloud data. The latter "-" is determined using only the GMS cloud data.

Figure 12-a Moisture analysis at 850mb level including the new satellite cloud moisture data at 1200UTC 24, June 1986. Contour interval is 3K. The area where T-TD is lower than 3K is shaded.

Figure 12-b The same as Figure 12-a but for 700mb level.

Figure 12-c The same as Figure 12-a but for 500mb level.

Figure 12-d The same as Figure 12-a but for 400mb level.

Figure 13 Comparison between the Test analysis and the Control analysis at 500mb in the southern hemisphere. (Top) Test analysis with not only the TEMP data but also satellite cloud moisture data. (Bottom) Control analysis with only the TEMP data. Contour interval is 3K and the area where T-TD is lower than 3K is shaded.

Figure 14-a Comparison between the Test analysis and the Control analysis at 850mb in the northern hemisphere. (Top) Test analysis with the new satellite cloud moisture data. (Bottom) Control analysis with the conventional T-TD bogus data. Contour interval is 3K and the region where T-TD is lower than 3K is shaded.

Figure 14-b The same as Figure 14-a but for 500mb level.

Figure 15 Infrared satellite photograph by GMS-3 at 0000UTC 26 August 1986.

Figure 16-a Surface weather chart at 0000UTC 26 August 1986.

Figure 16-b Surface weather chart at 1200UTC 27 August 1986.

Figure 17 T-TD analyses at 0000UTC 26 August 1986. Relatively humid regions where T-TD=3K are shaded. (Left) the analyses of Test run and (Right) those of Control run. (Top) at 850mb and (Bottom) at 700mb.

Figure 18 Comparison of the forecasted sea level pressure and precipitation by Test run (Left column) and Control run(Right column). The contour interval of PS is 4mb. Precipitation areas are shaded and the contour interval of the accumulated precipitaions is 5mm/6hour. (Top) Initial Ps and precipitation during 0 to 12 forecast hours, (Middle) Ps at 24 hour forecast and precipitation during 12 to 24 forecast hours, and (Bottom) Ps at 36 hour forecast and precipitation during 24 to 36 forecast hours.

Figure 19 12hour total precipitations from SYNOP and SHIP observations. (Top) for the first 12 hour (from 0000UTC 26 August to 1200UTC 26), (Middle) for the second 12 hour period (from 1200UTC 26 to 0000UTC 27), and (Bottom) for the third 12 hour period (from 0000UTC 27 to 1200UTC 27).

Figure 20 Cloud distributions represented by the mean T_{BB} at cloud top on 0000UTC 26 August (Top), 1200UTC 26 (Second), 0000TC 27 (Third), and 1200UTC 27 (Bottom). The contours represent cloud top temperature for every -10°C from -5°C.

Table 1 Contents of GMS cloud data

	Contents	unit
1	cloud amount - 400mb	%
2	cloud amount 400mb - 500mb	%
3	cloud amount 500mb - 600mb	%
4	cloud amount 600mb - 700mb	%
5	cloud amount 700mb -	%
6	mean of T_{BB} on cloud top	K
7	minimum of T_{BB}	K
8	standard deviation of T_{BB}	K
9	sea surface temperature(10 day mean)	K

Table 2 Elements used to classify the cloud condition. Each elements are classified into several groups. The cloud conditions are defined by the combination of these elements.

GMS T_{BB} data			Synoptic observations			Locations
Total cloud amount (%)	Standard deviation of T_{BB} (K)	Mean T_{BB} level (mb)	ww	h	Nh	
0						
1 - 10	0.0 - 4.0	- 450	13-29,38-99	8,9		23.5N-23.5S
10 - 50	4.0 -	450 - 660	00-12,30-37	0-7,missing	2-9,missing	50.0N-23.5N,23.5S-50.0S
50 - 80		660 - 810	missing			
80 - 99		810 -				
100						

Table 3-1 Combinations of elements for cloud conditions
No.1 - No.132

Location*1)	Tropics			Subtropics			GMS T_{BB} data Total cloud amount (%)	mean T_{BB} level (mb)	S.D. of T_{BB} (K)
SYNOP data*2)	Wet	Dry	Free	Wet	Dry	Free			
	1	23	45	67	89	111	0	-	-
	2	24	46	68	90	112	1 - 10	-	-
	3	25	47	69	91	113	10 - 50	- 450	-
	4	26	48	70	92	114	10 - 50	450 - 660	-
	5	27	49	71	93	115	10 - 50	660 - 810	-
	6	28	50	72	94	116	10 - 50	810 -	-
	7	29	51	73	95	117	50 - 80	- 450	-
	8	30	52	74	96	118	50 - 80	450 - 660	-
	9	31	53	75	97	119	50 - 80	660 - 810	-
	10	32	54	76	98	120	50 - 80	810 -	-
	11	33	55	77	99	121	80 - 99	- 450	-
	12	34	56	78	100	122	80 - 99	450 - 660	-
	13	35	57	79	101	123	80 - 99	660 - 810	-
	14	36	58	80	102	124	80 - 99	810 -	-
	15	37	59	81	103	125	100	- 450	0.0 - 4.0
	16	38	60	82	104	126	100	450 - 660	0.0 - 4.0
	17	39	61	83	105	127	100	660 - 810	0.0 - 4.0
	18	40	62	84	106	128	100	810 -	0.0 - 4.0
	19	41	63	85	107	129	100	- 450	4.0 -
	20	42	64	86	108	130	100	450 - 660	4.0 -
	21	43	65	87	109	131	100	660 - 810	4.0 -
	22	44	66	88	110	132	100	810 -	4.0 -

*1) Tropics; 23.5N-23.5S Subtropics; 50.0N-23.5N,23.5S-50.0S
*2) Wet; ww=13-29,38-99 Dry; ww=00-12,30-37 Free; no observations

Table 3-2 Combinations of elements for cloud conditions.
No.133 - No.141

cloud condition No.	GMS T_{BB} data Total cloud amount (%)	mean T_{BB} level (mb)	S.D. of T_{BB} (K)	SYNOP observation ww *1)	h	Nh	location *2)
133	50 - 80	- 450	-	Dry	8,9	0,1	Subtropics
134	80 - 99	- 450	-	Dry	8,9	0,1	Subtropics
135	80 - 99	450 - 660	-	Dry	8,9	0,1	Subtropics
136	100	- 450	0.0 - 4.0	Dry	8,9	0,1	Subtropics
137	100	450 - 660	0.0 - 4.0	Dry	8,9	0,1	Subtropics
138	100	660 - 810	0.0 - 4.0	Dry	8,9	0,1	Subtropics
139	100	- 450	4.0 -	Dry	8,9	0,1	Subtropics
140	100	450 - 660	4.0 -	Dry	8,9	0,1	Subtropics
141	100	660 - 810	4.0 -	Dry	8,9	0,1	Subtropics

*1) Wet; ww=13-29,38-99 Dry; ww=00-12,30-37 Free; no observations
*2) Tropics; 23.5N-23.5S Subtropics; 50.0N-23.5N,23.5S-50.0S

Table 4 Reduction of the number of data due to quality control

level(mb)	total number	final number	reduction ratio
1000	627	565	0.10
950	672	584	0.13
900	672	600	0.11
850	672	598	0.11
800	671	579	0.14
750	661	564	0.15
700	658	544	0.17
650	646	519	0.20
600	639	517	0.19
500	629	540	0.14
400	613	465	0.24

Table 5 Process to determine the typical T-TD value at each level for cloud condition No.56

level(mb)	mean T-TD	peak T-TD	determined T-TD	reason of the determination
1000	3.2	3.2	3.2	mean,peak
950	2.2	1.8	1.8	peak
900	2.1	1.5	1.5	peak
850	2.5	1.7	1.7	peak
800	3.3	2.5	2.5	peak
750	4.8	3.2	3.2	peak
700	6.3	3.8	3.8	peak
650	7.5	4.3	4.3	peak
600	8.9	4.5	7.4	(2*peak+mean)/3
500	12.5	4.8	9.9	(2*mean+peak)/3
400	13.4	16.2	13.4	mean

Table 6 The numbers of the estimated satellite moisture data for each cloud condition At 1200UST 24 June 1986.

Tropical region (23.5N - 23.5S) -- Total 1054																						
Wet*1)	0	0	0	1	2	0	0	0	1	0	8	1	1	0	0	0	0	0	11	1	0	0
Dry*2)	12	10	0	7	13	2	1	7	1	0	10	10	1	0	0	1	0	0	20	1	0	0
Free*3)	142	133	3	38	125	11	7	52	47	1	105	85	21	0	4	7	0	0	129	20	2	0
Subtropical region (50.0N-23.5N,23.5S-50.0S) -- Total 987																						
Wet	2	1	1	0	0	7	0	0	0	2	5	3	0	2	0	1	0	1	3	4	0	1
Dry	21	8	1	5	0	7	0	5	2	5	0	1	0	8	1	0	0	0	0	3	1	0
Free	174	63	0	33	75	47	5	69	38	32	42	82	27	42	7	7	7	4	62	43	10	5
Dry2*4)	0	0	6	0	1	0	3	1	1													

*1) With synoptic observations, ww=13-29,38,99
*2) With synoptic observations, ww=00-12,30-37
*3) No use of synoptic observations
*4) With synoptic observations, ww=00-12,30-37, h=8,9, Nh=0,1

Table 7 Bias and RMS of the satellite cloud moisture data to the T-TD by sonde data in Pacific Ocean during November 1986.

level (mb)	Satellite moisture data Bias	RMS
850	-0.9	3.2
700	-4.3	8.0
500	-4.2	8.5
400	-4.2	8.4

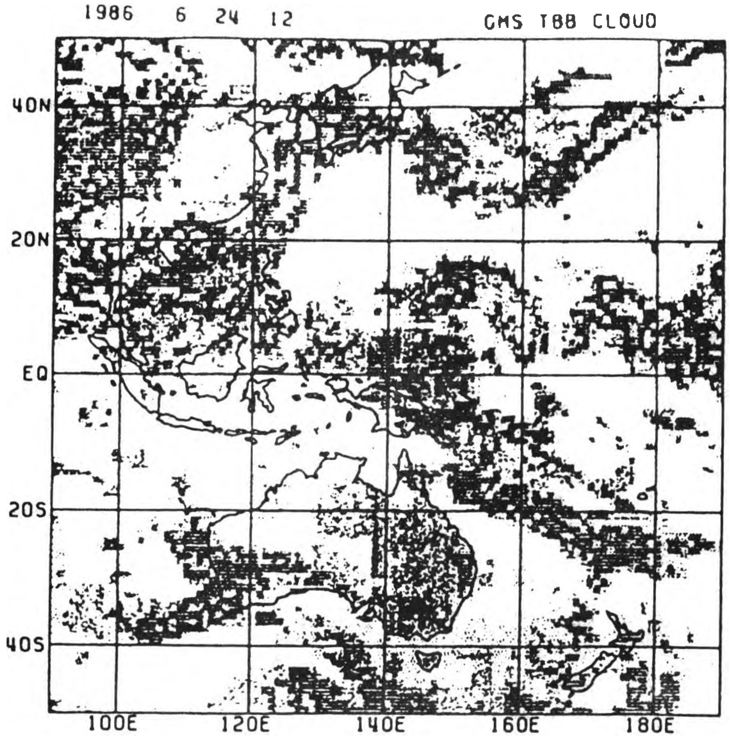


Figure 1-a Cloud distribution represented by the total cloud amount calculated by GMS cloud data at 1200UTC 24,June 1986. Areas with larger cloud amount are shaded darker.

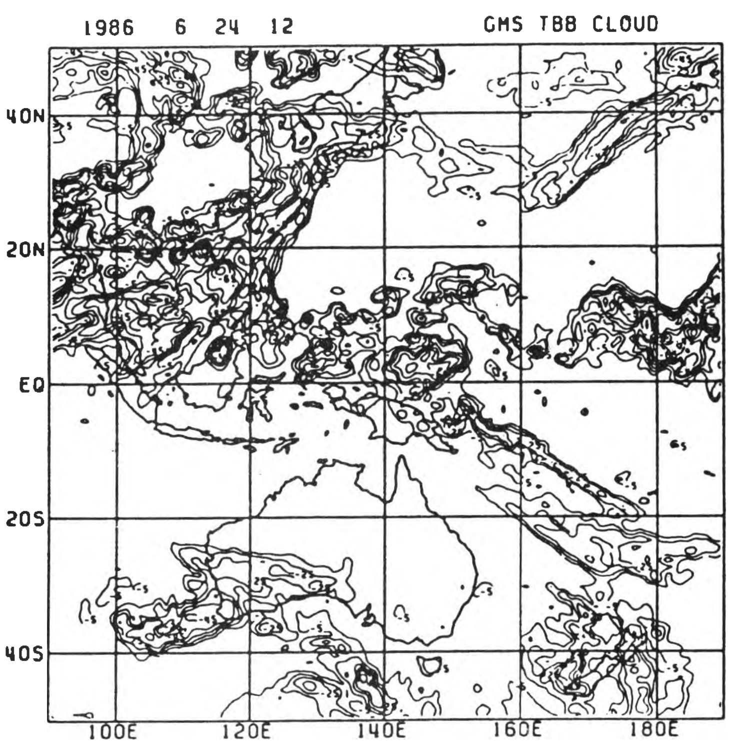


Figure 1-b Cloud distribution represented by the mean T_{BB} at cloud top at the same time as Figure 1-a. The contours are drawn in regions where the T_{BB} is lower than -5°C. The contour interval is 10°C.

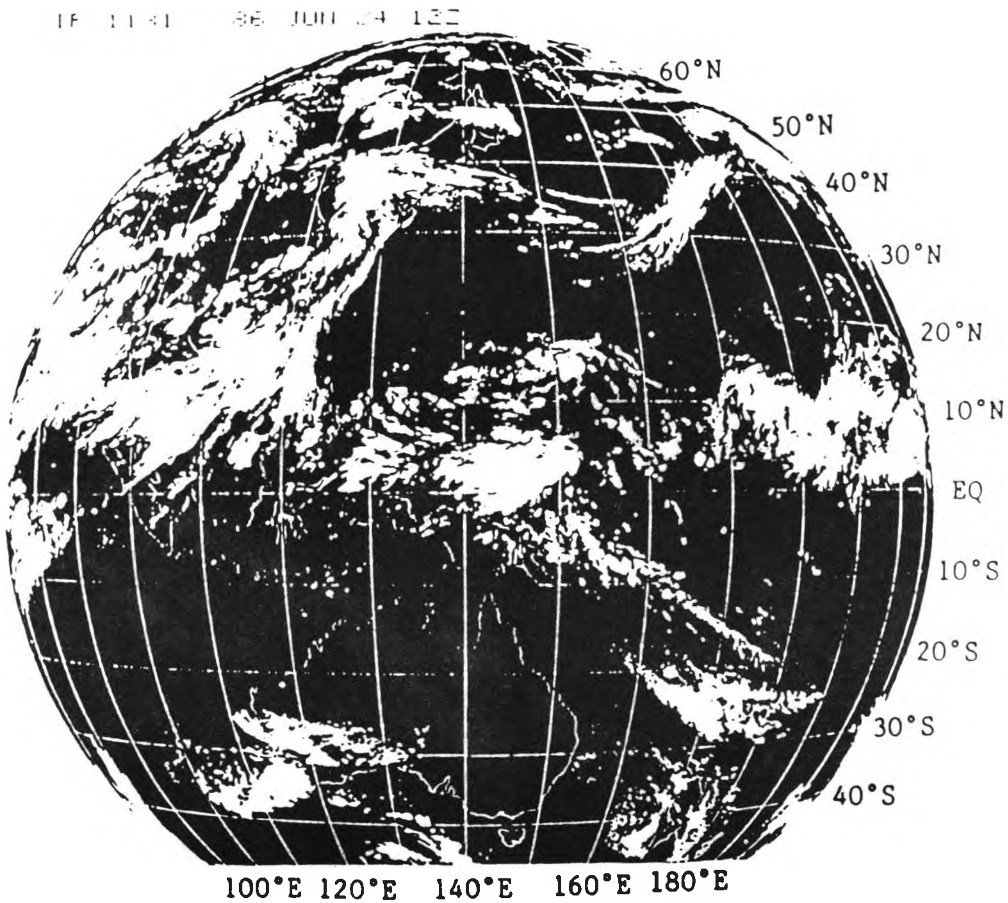


Figure 2 GMS-3 infrared satellite photograph at 1200UTC 24,June 1986.

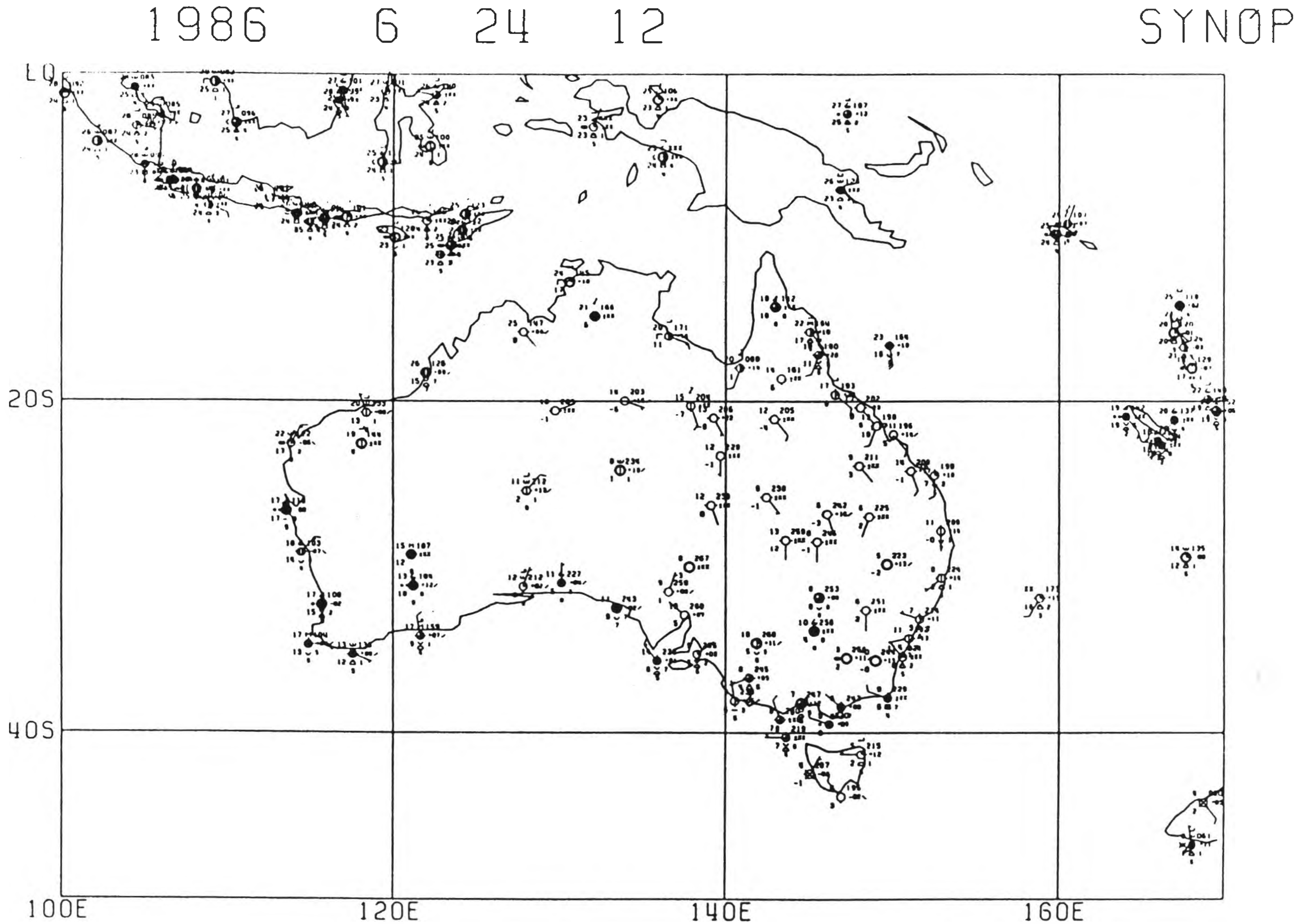


Figure 3 Synop observations around Australia at 1200UTC 24, June 1986.
Observation time of them are from 1000UTC to 1400UTC.

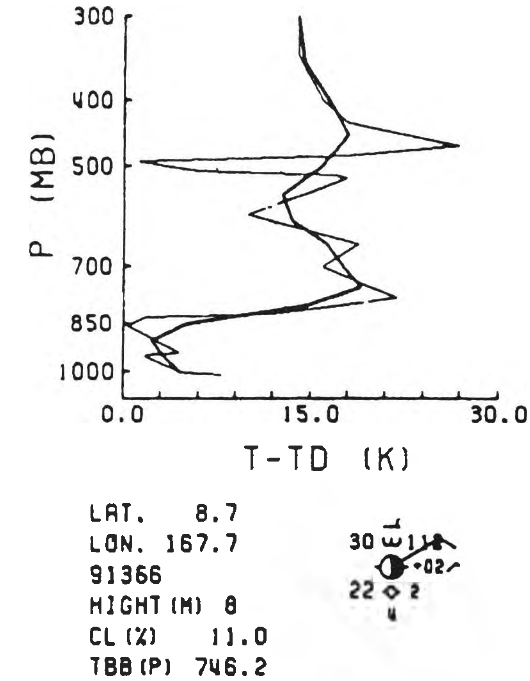


Figure 4 An example of the smoothing of a vertical profile of T-TD. Thin line is the original(observed) profile and thick line is the smoothed profile. CL(%) and TBB(p) are the total cloud amount and mean cloud top level(mb) by GMS cloud data at the station, respectively.

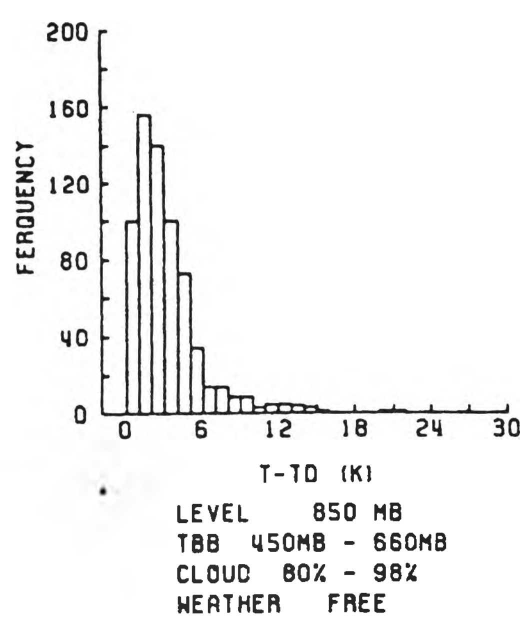


Figure 5 A histogram for smoothed TEMP T-TD data at 850mb level of the cloud condition No.56.

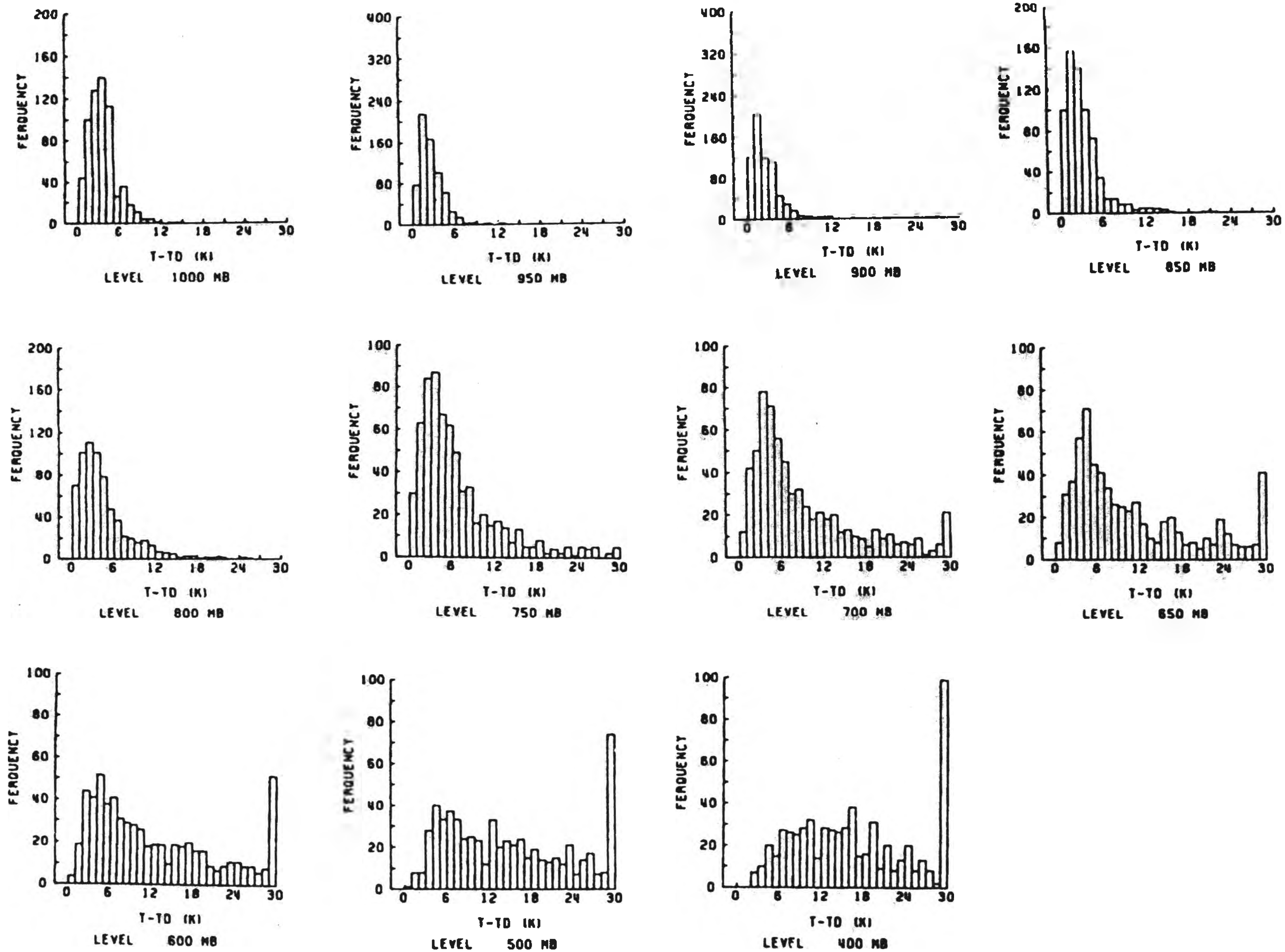


Figure 6 Histograms of the smoothed TEMP T-TD data at every 50mb level from 1000mb up to 600mb and at 500mb and 400mb for the cloud condition No.56. In some areas, when the relative humidity is less than 20%, the dew point depression is fixed to 30K. Therefore, the frequency at 30K is large at

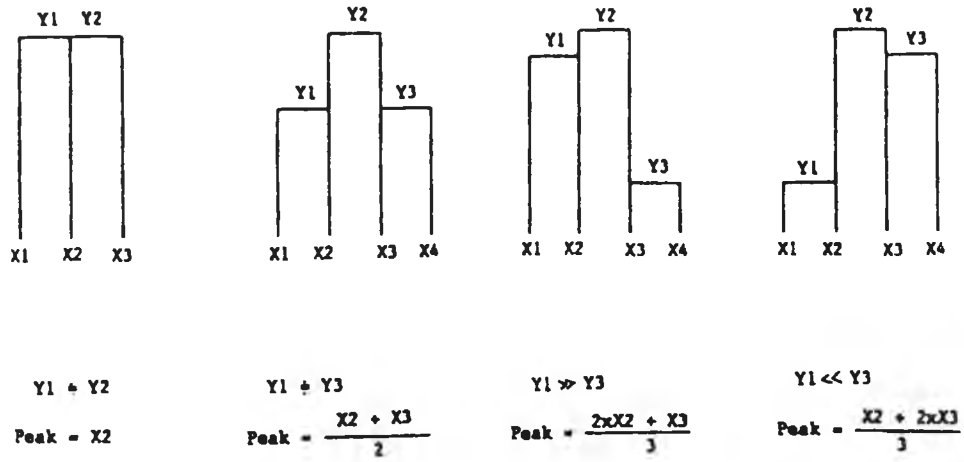


Figure 7 Definition of the "Peak" value.

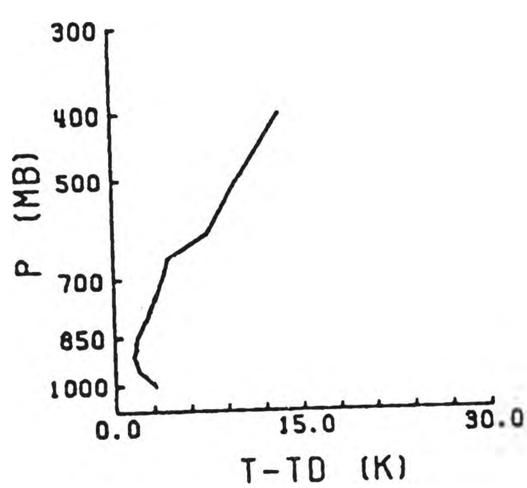


Figure 8 Determined T-TD profile for the cloud condition No.56.

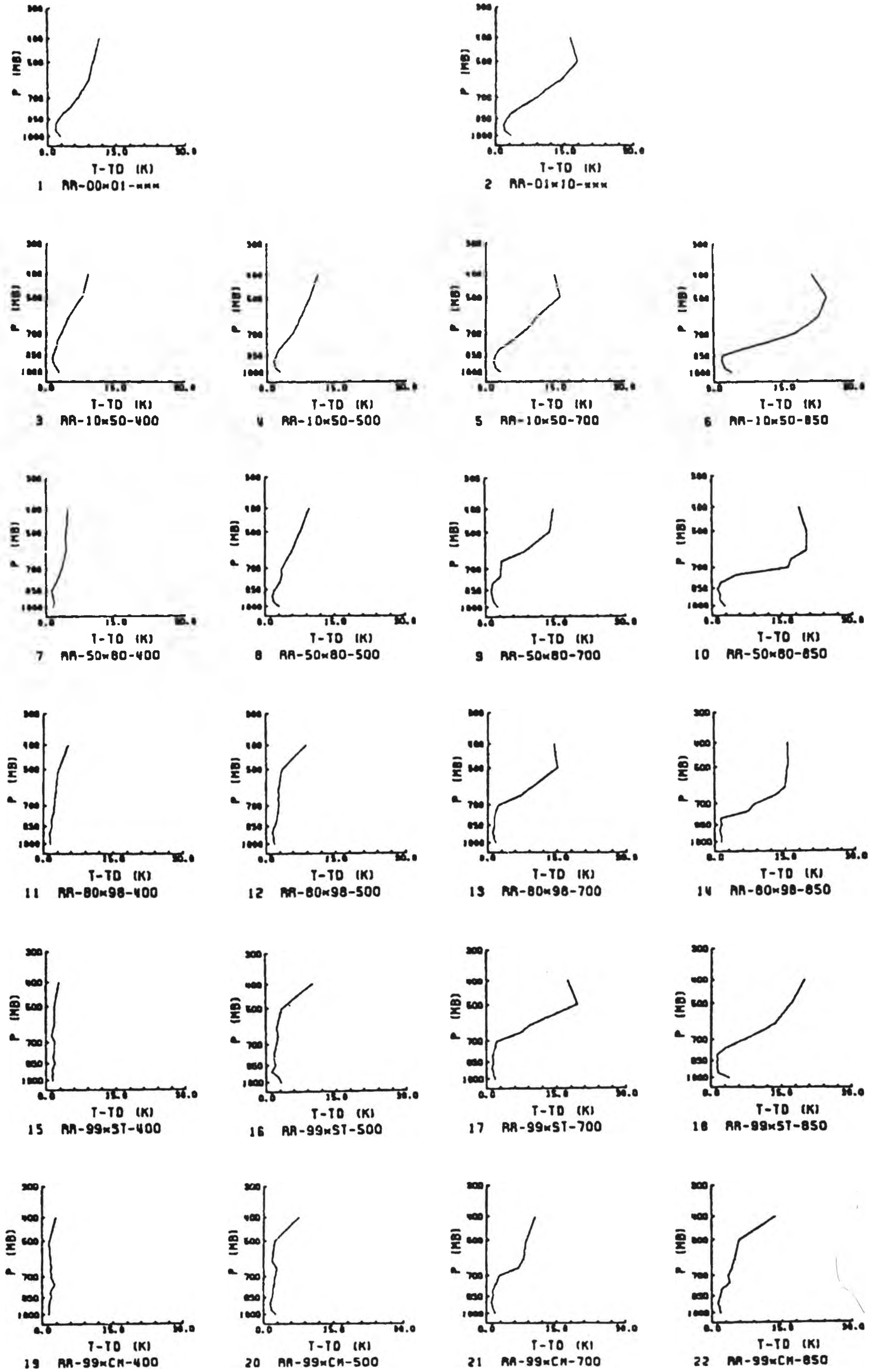


Figure 9-a Determined T-TD profiles for cloud conditions No.1-No.22. "Present weather" is Wet and location is tropics.

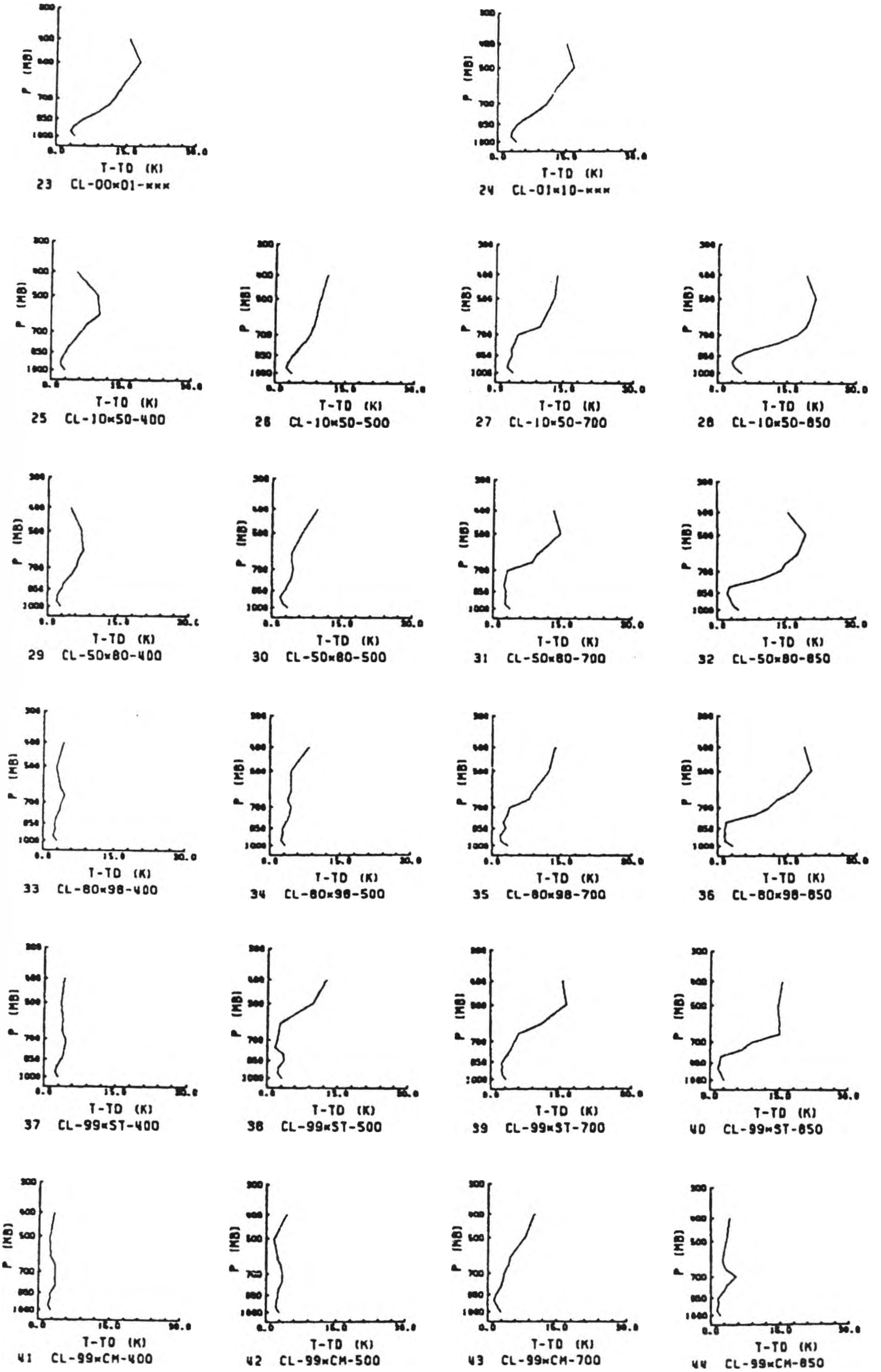


Figure 9-b The same as Figure 9-a but cloud conditions No.23-No.44 and present weather is Dry.

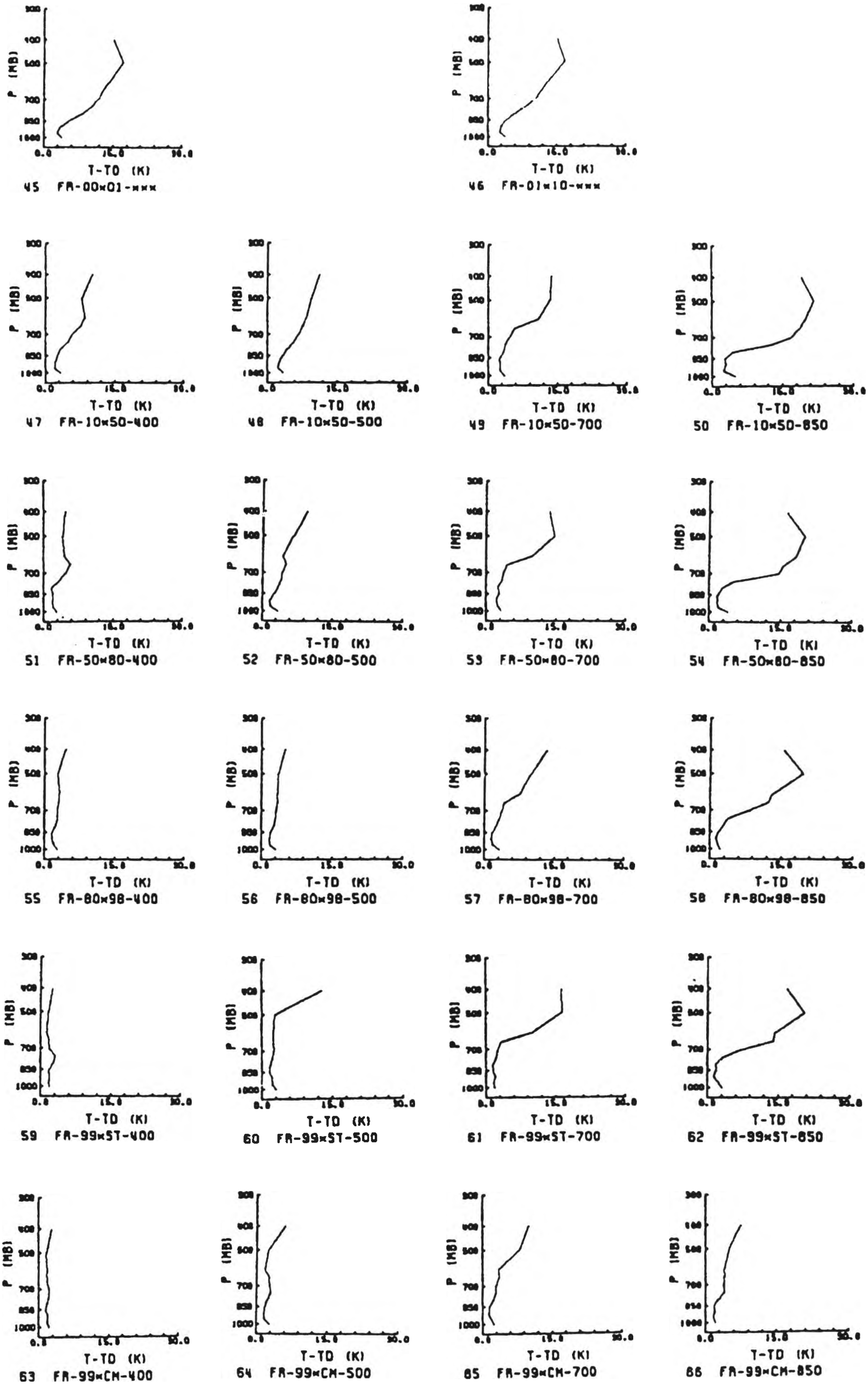


Figure 9-c The same as Figure 9-a but cloud conditions No.45-No.66 and present weather is Free.

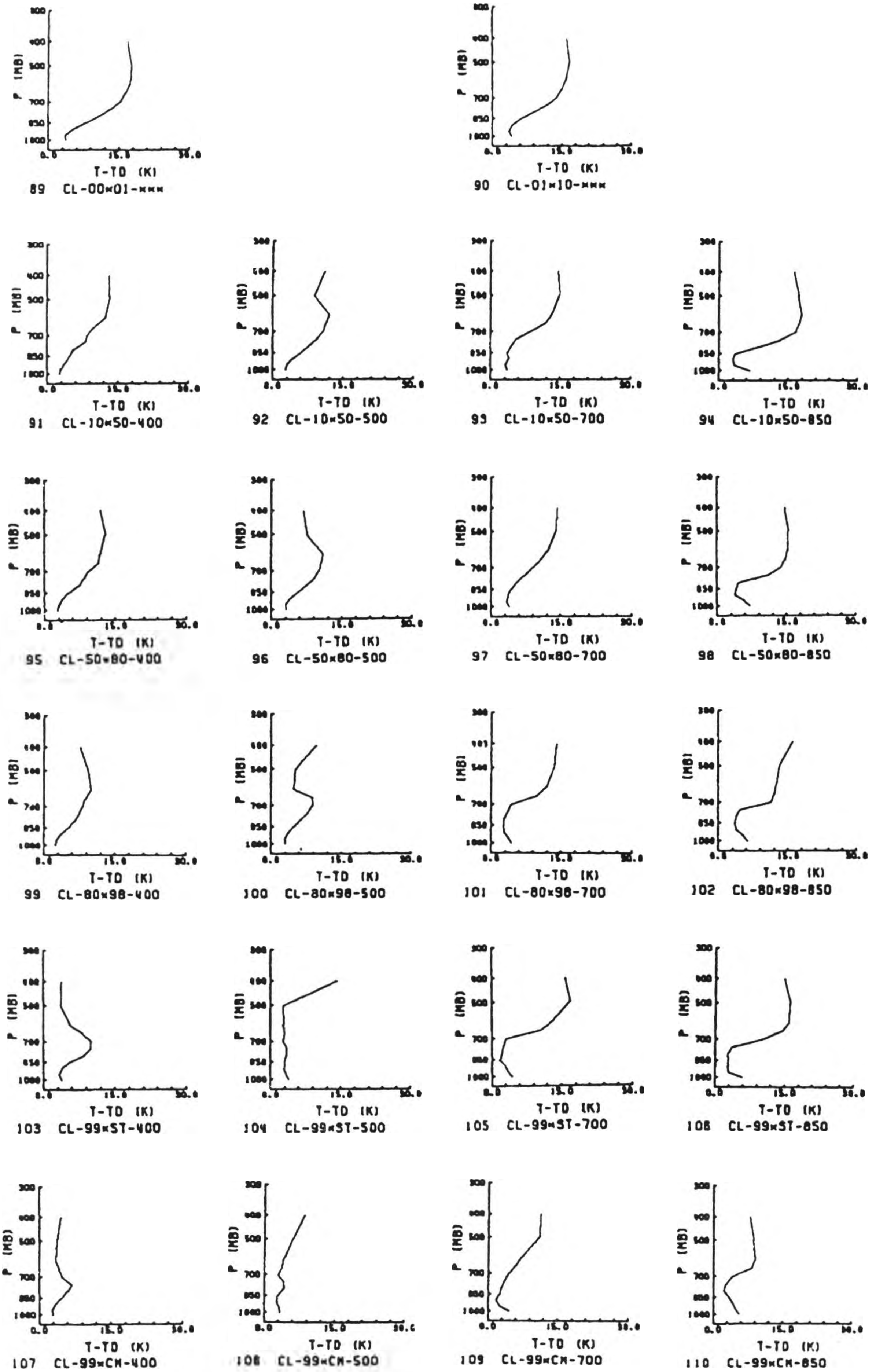


Figure 9-d The same as Figure 9-a but cloud conditions No.67-No.88 and present weather is Wet and location is subtropics.

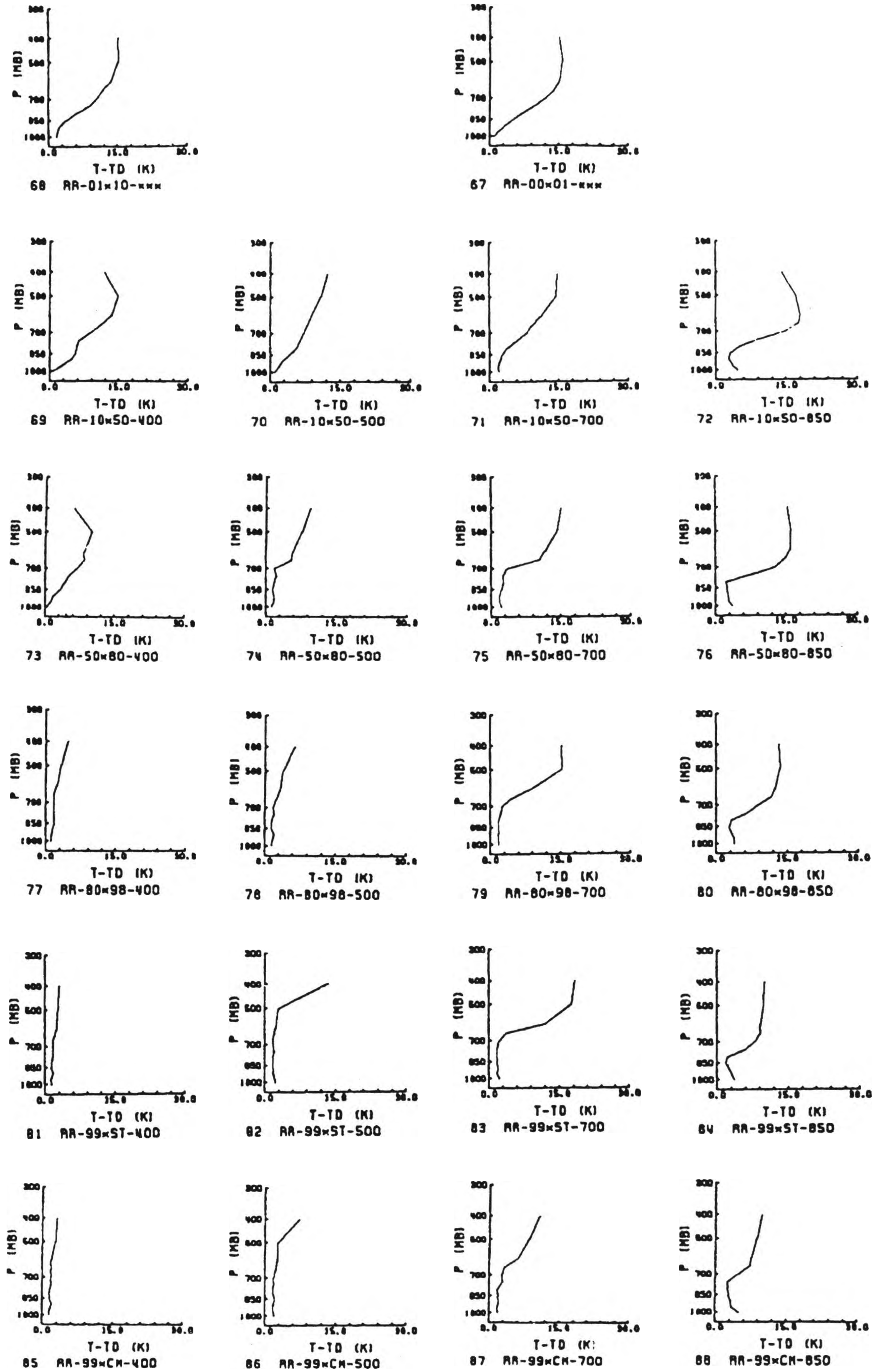


Figure 9-e The same as Figure 9-a but cloud conditions No.89-No.110 and cloud condition is Dry.

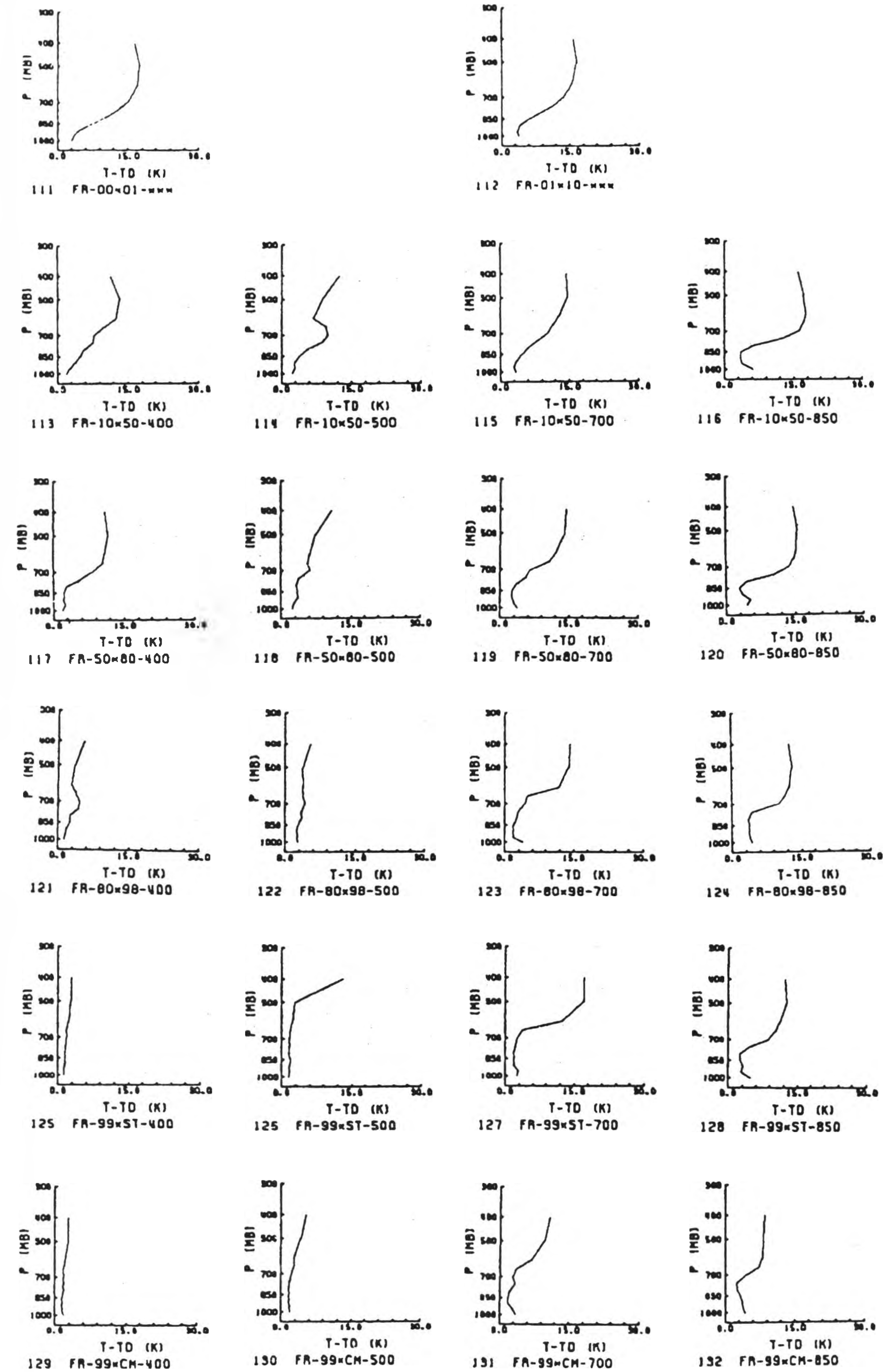


Figure 9-f The same as Figure 9-a but cloud conditions No.111-No.132 and present weather is Free.

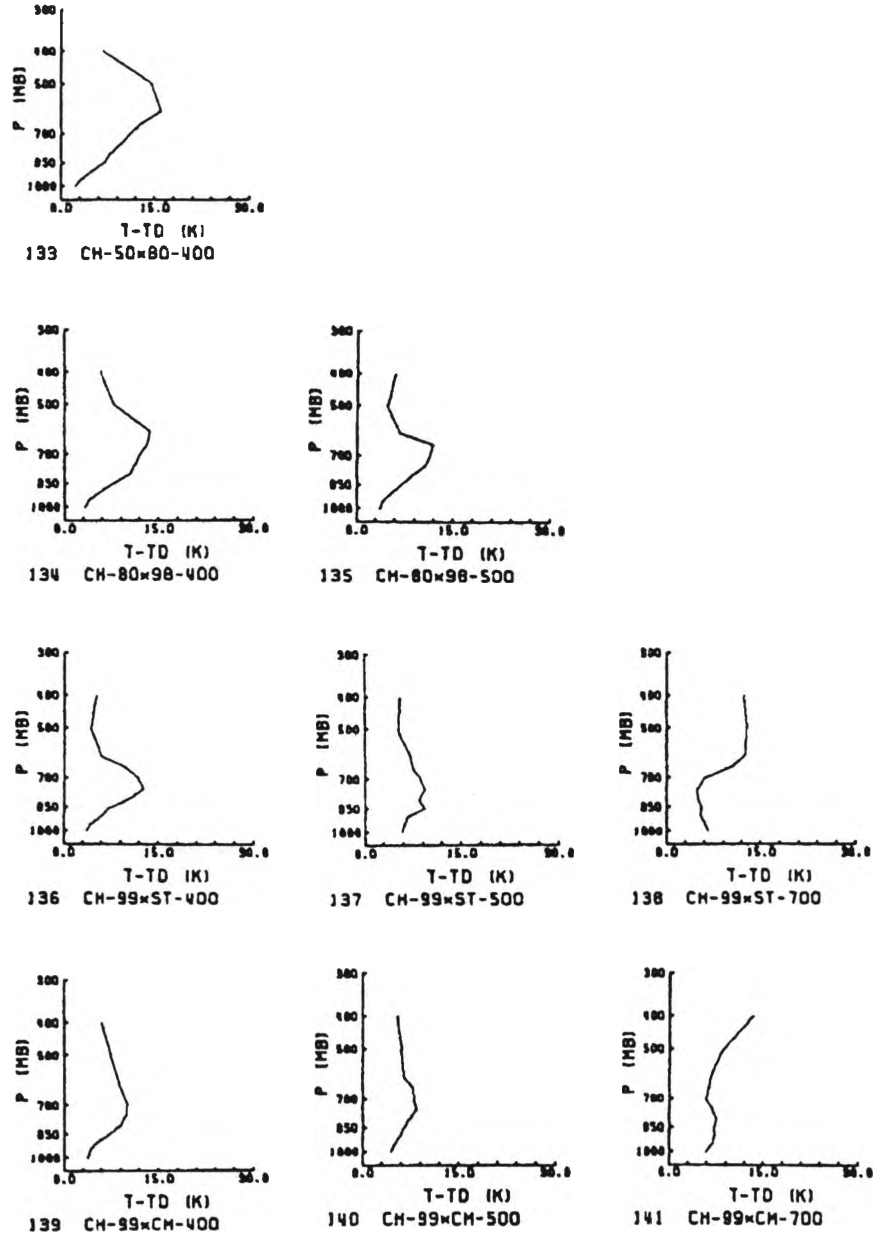


Figure 9-g As Figure 9-a but cloud conditions No.133-No.141 but present weather is Dry and sub-elements(h,Nh) are also used.

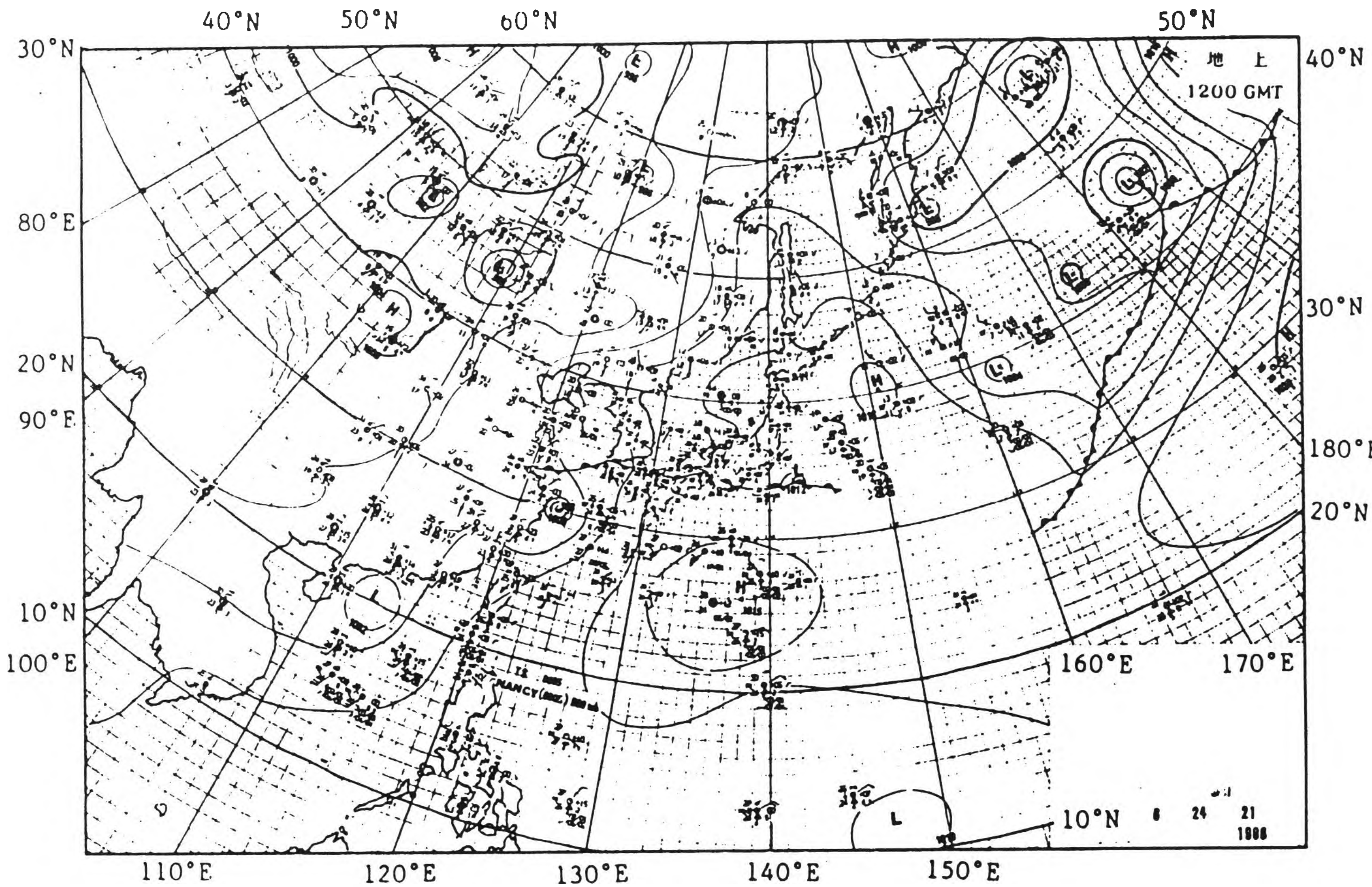
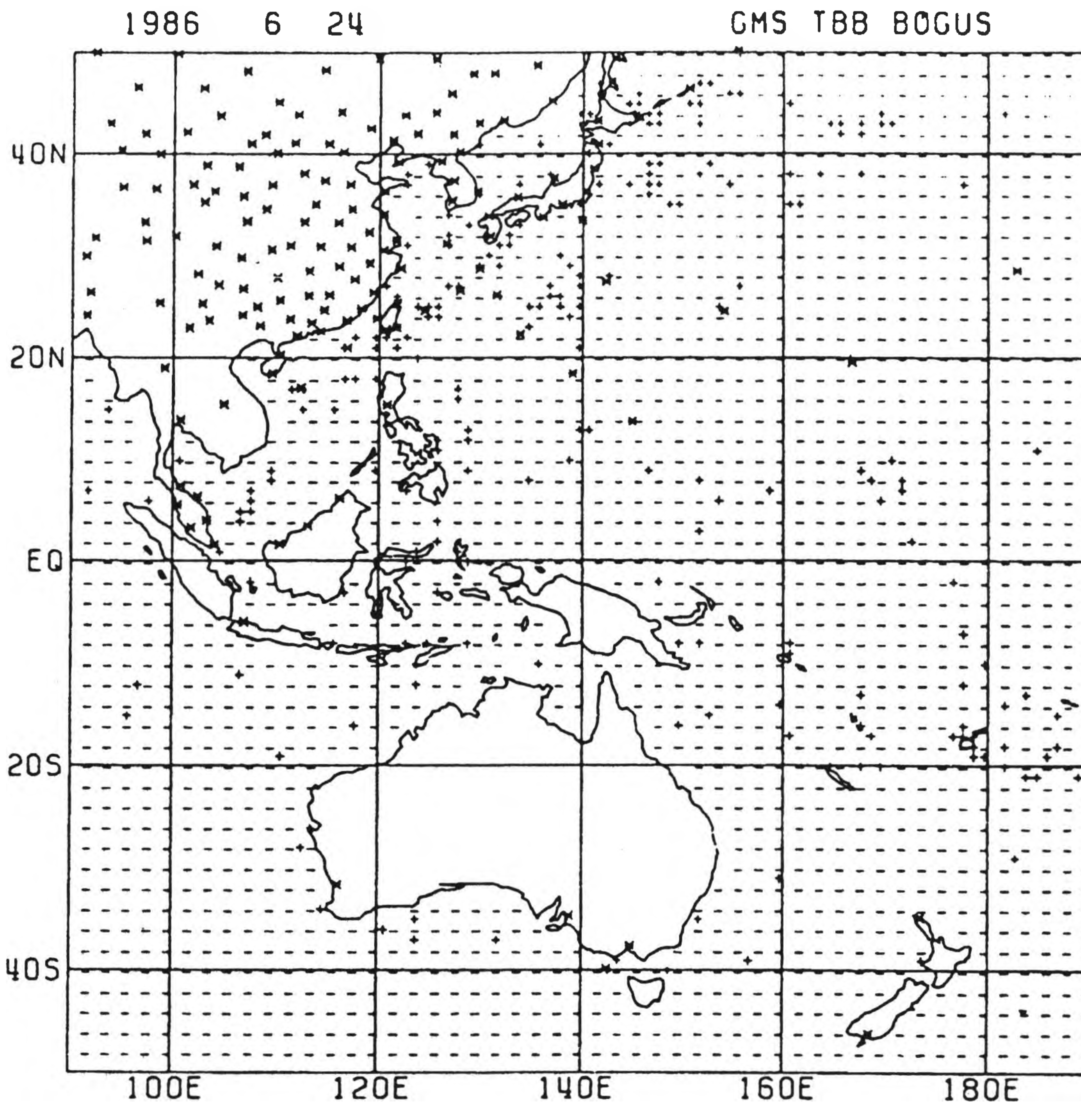


Figure 10 Surface weather chart at 1200UTC, 24 June 1986.



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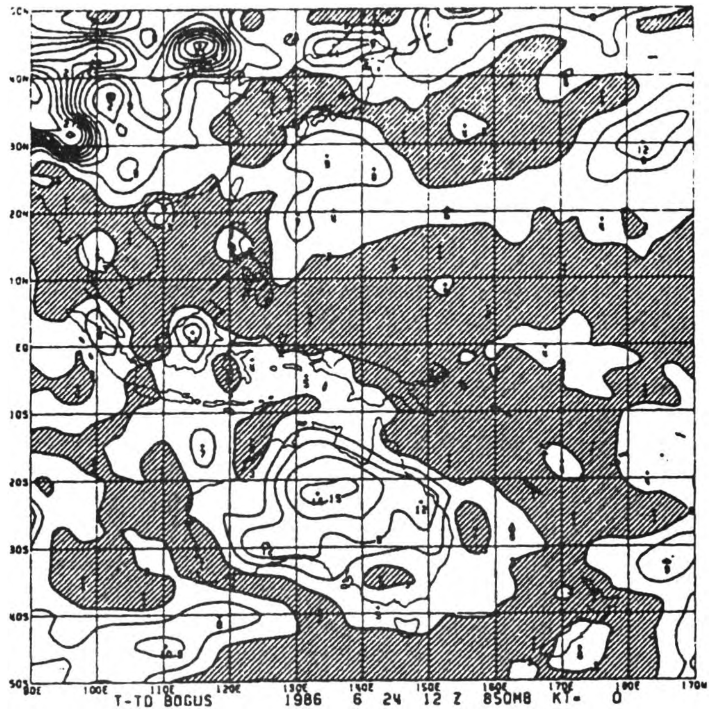

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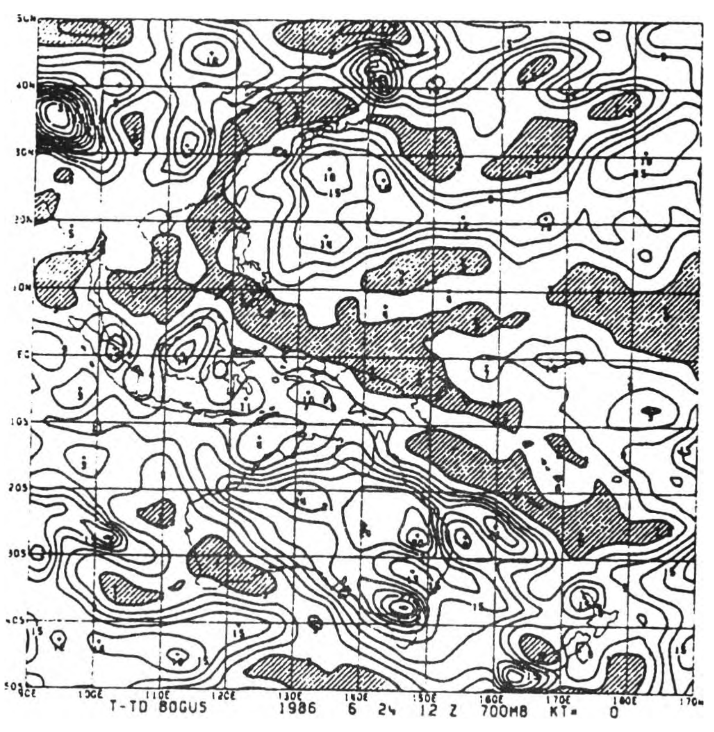


Figure 12-b The same as Figure 12-a but for 700mb level.

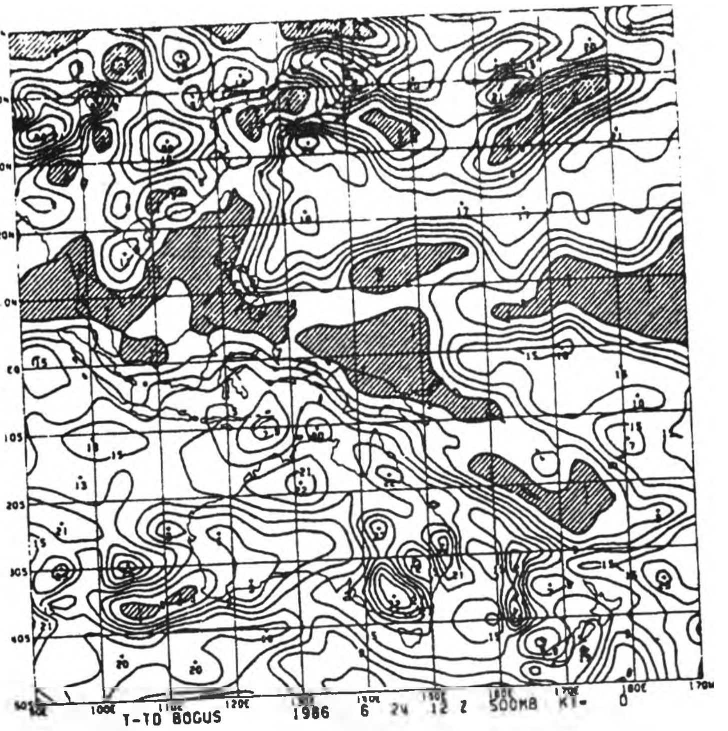


Figure 12-c The same as Figure 12-a but for 500mb level.

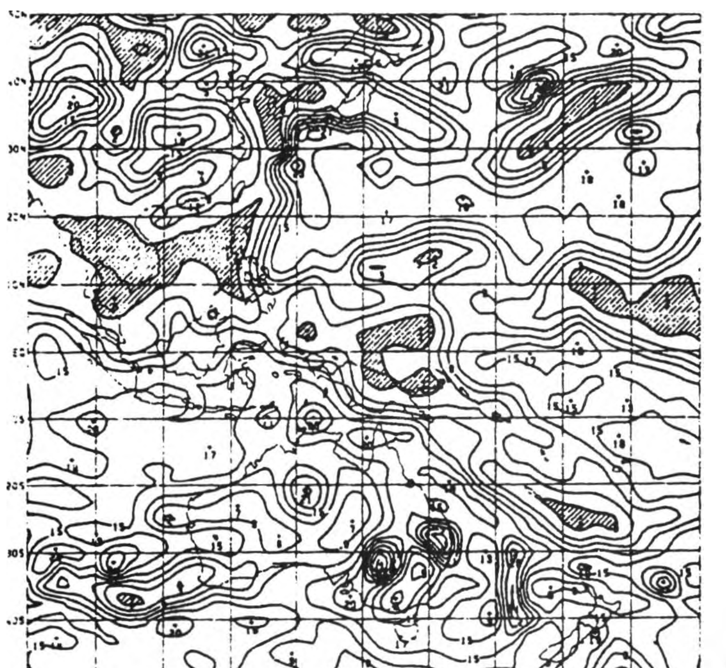
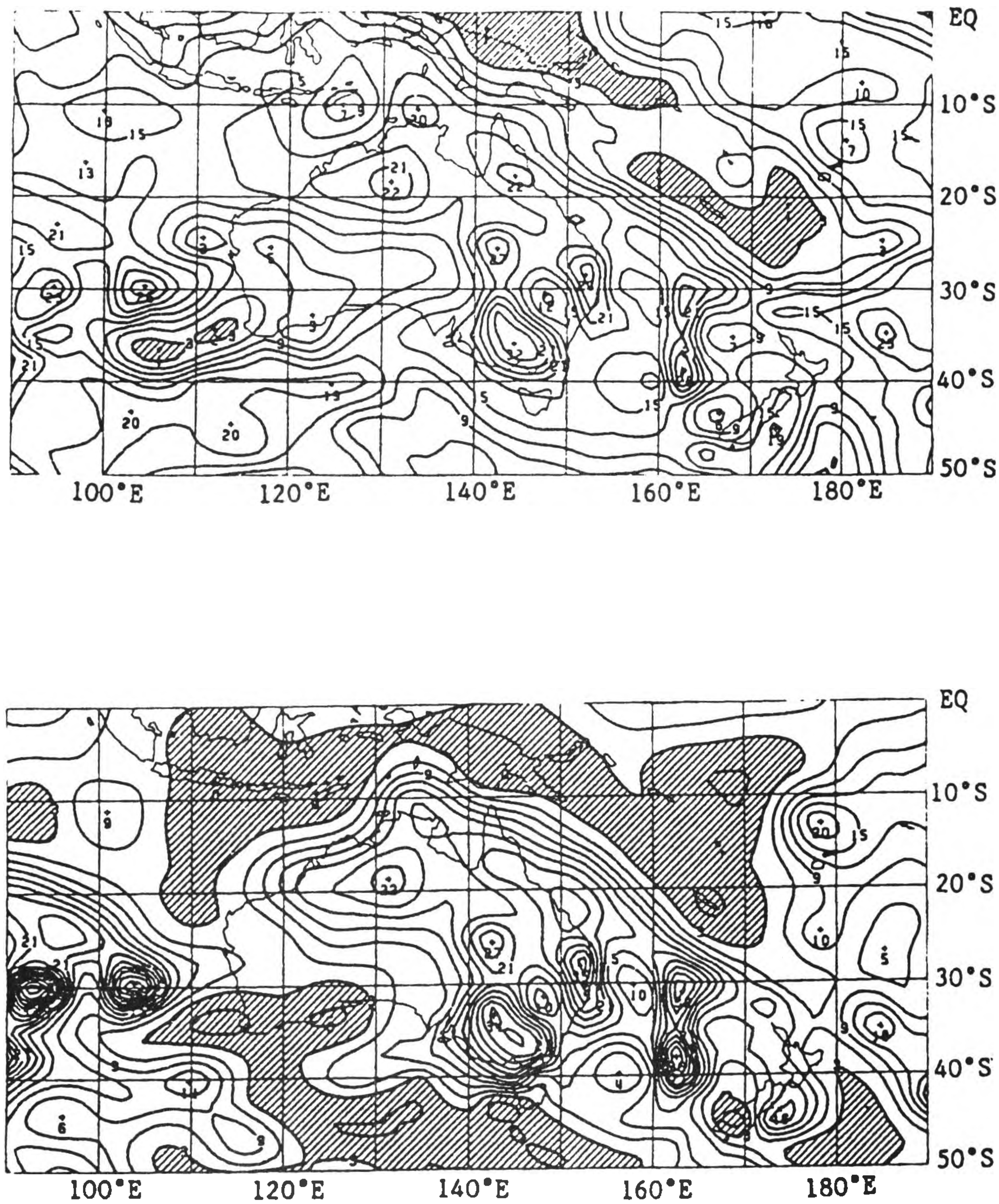


Figure 12-d The same as Figure 12-a but for 400mb level.



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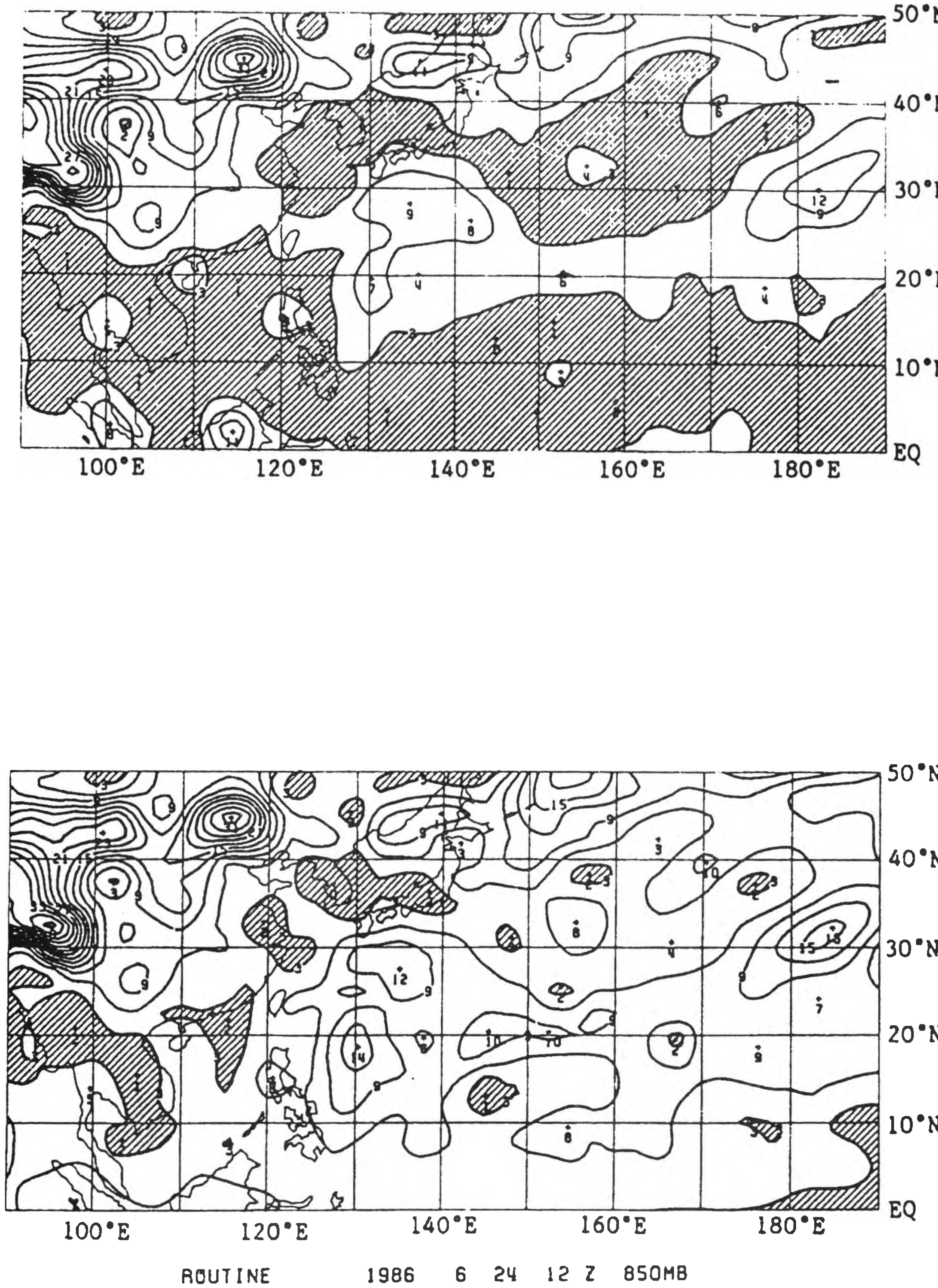

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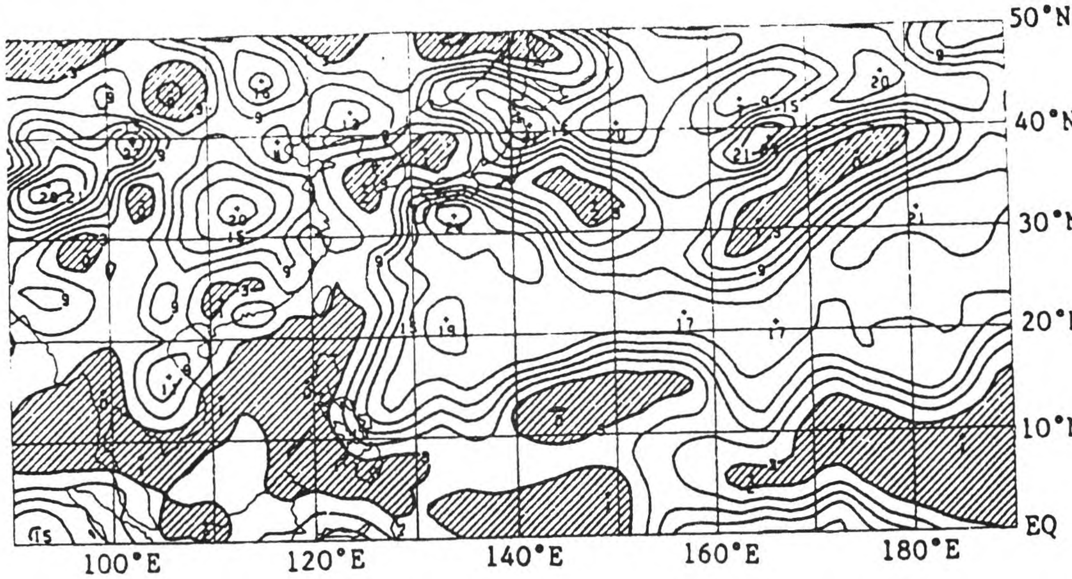

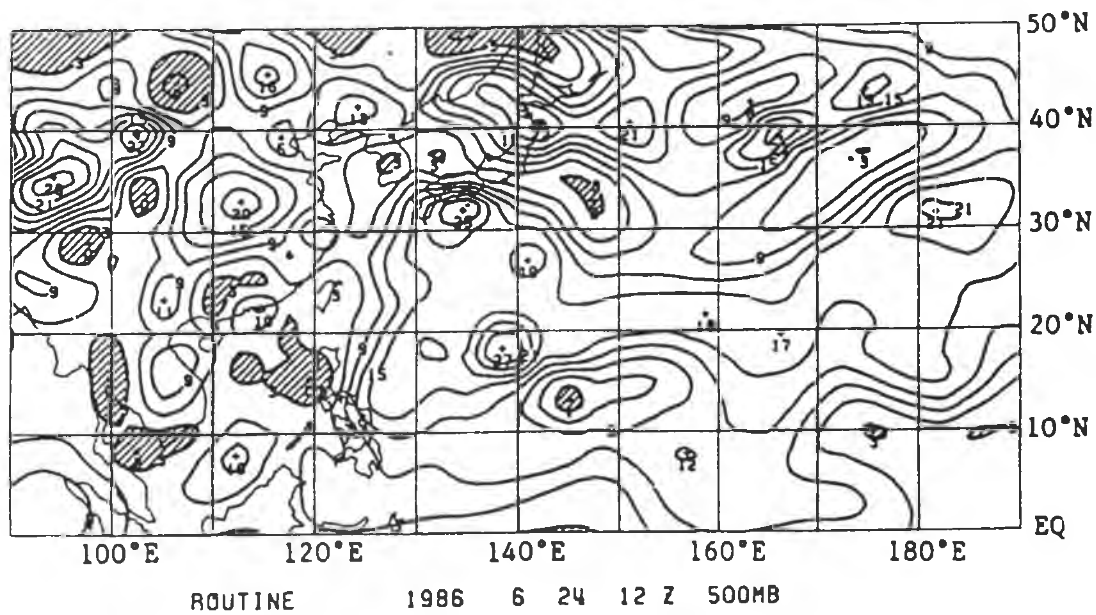

Figure 14-b The same as Figure 14-a but for 500mb level.

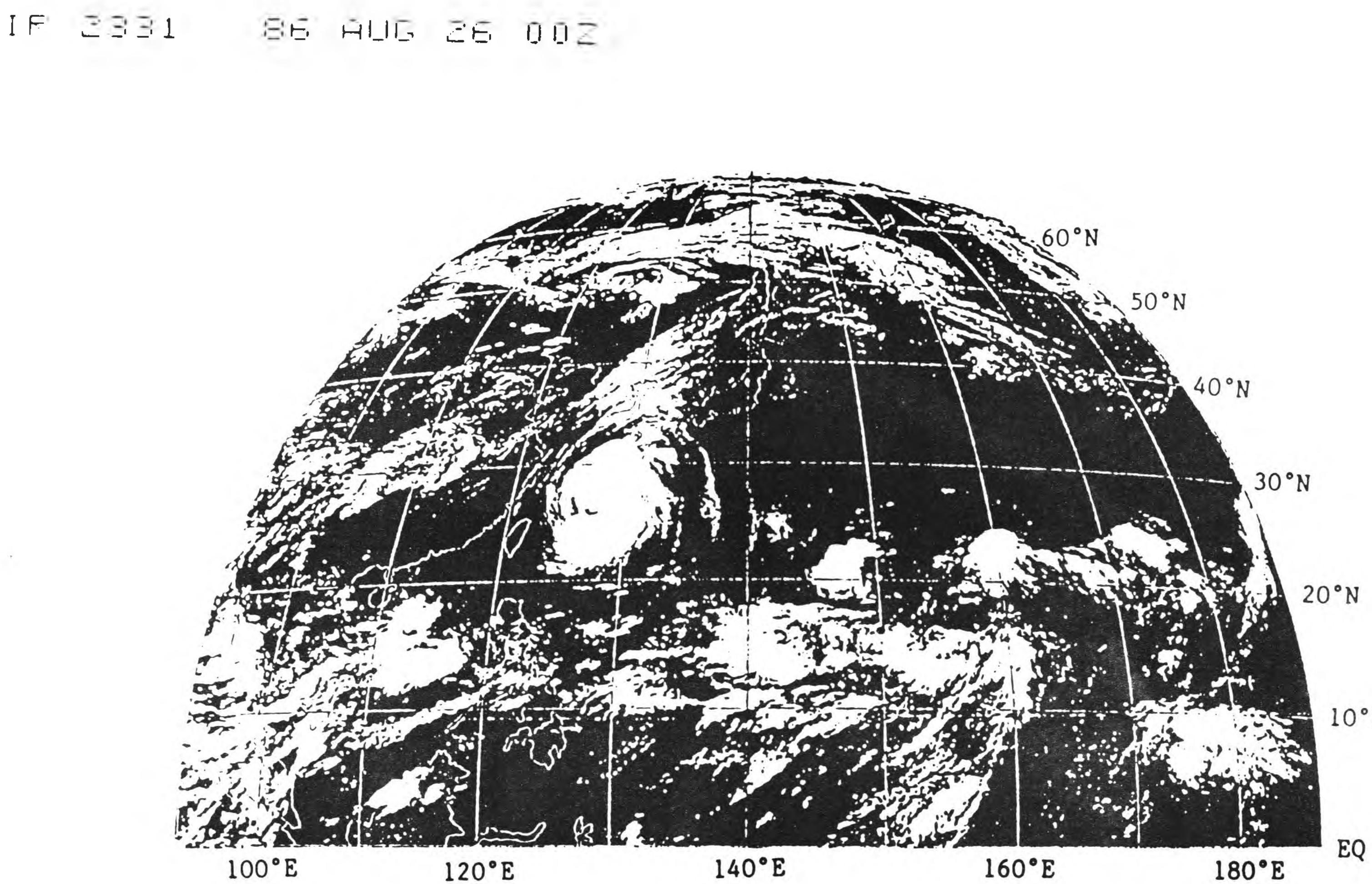

Figure 15 Infrared satellite photograph by GMS-3 at 0000UTC 26 August 1986.

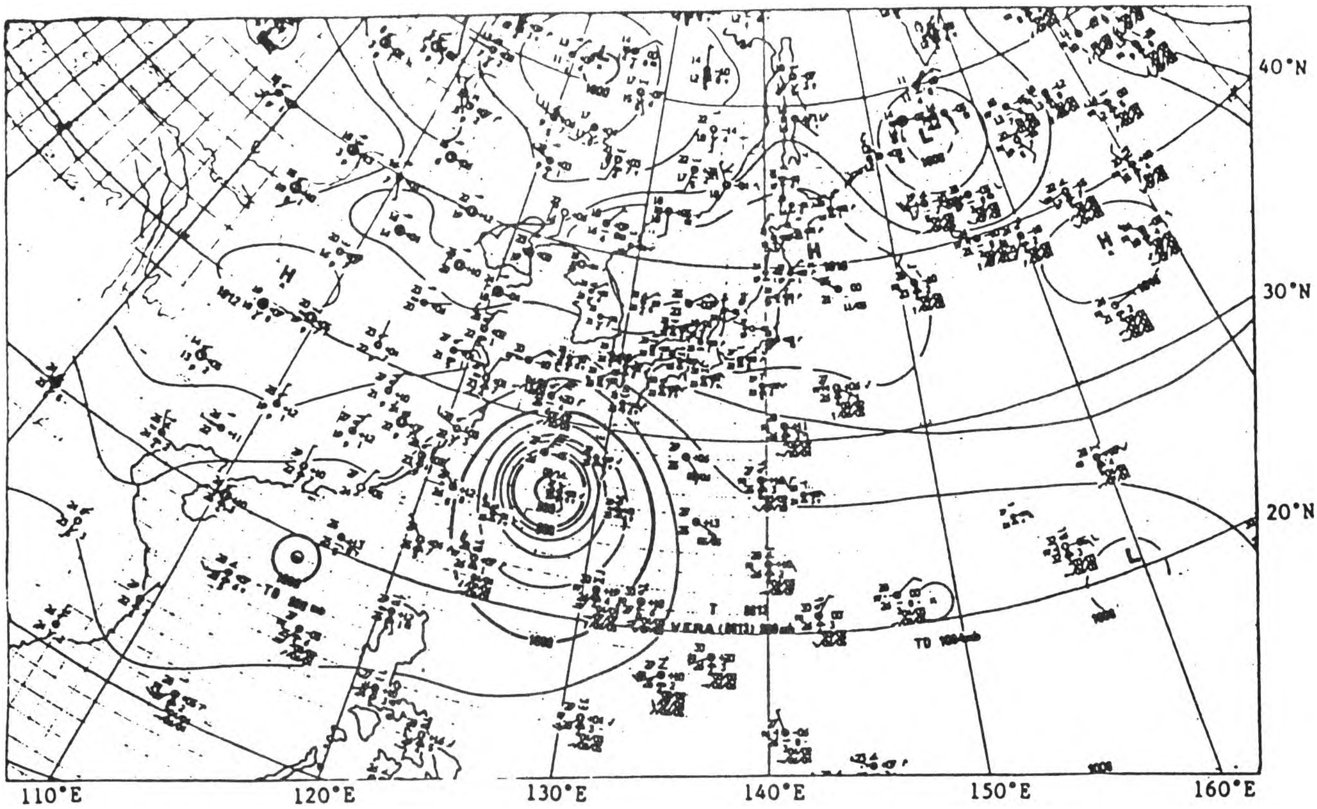

Figure 16-a Surface weather chart at 0000UTC 26 August 1986.

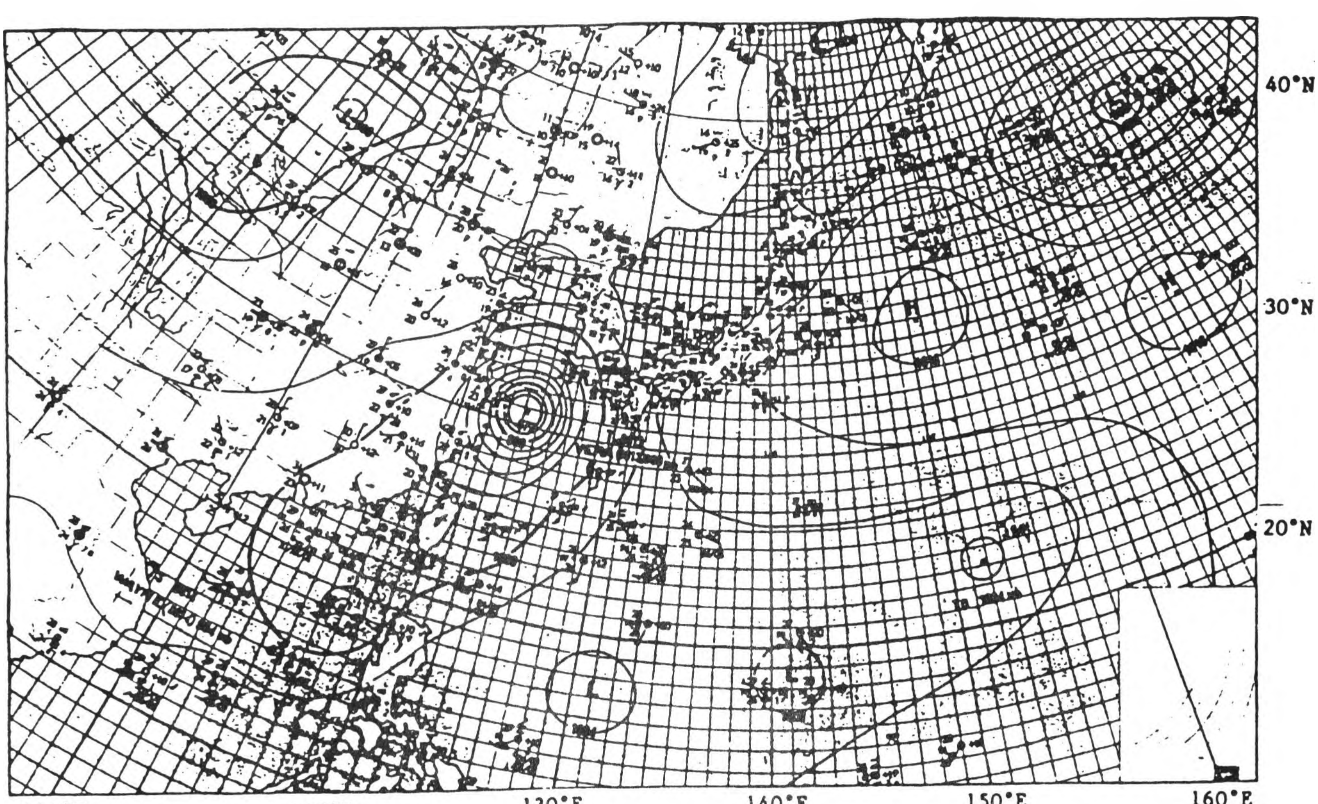

Figure 16-b Surface weather chart at 1200UTC 27 August 1986.

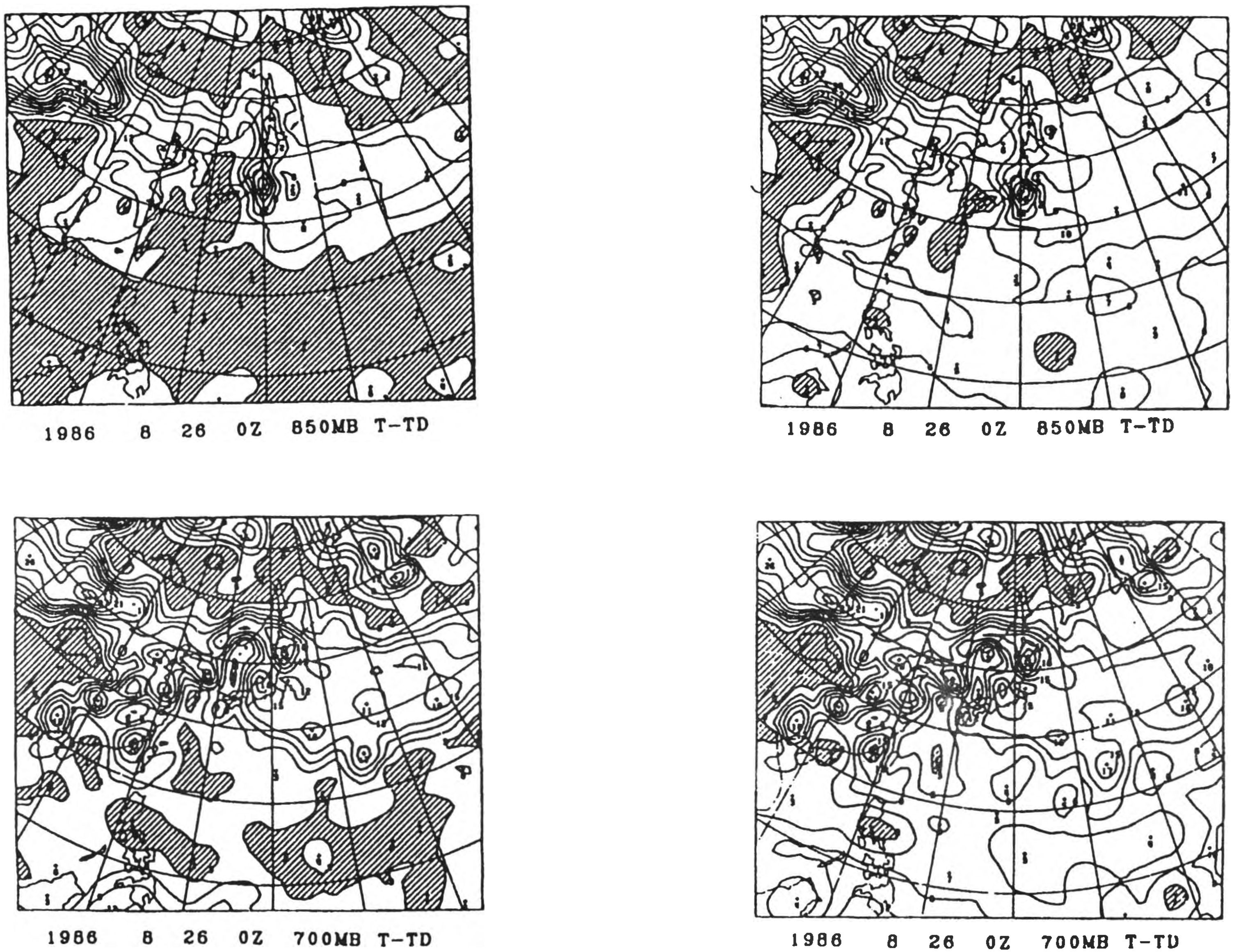

Figure 17 T-TD analyses at 0000UTC 26 August 1986. Relatively humid regions where T-TD=3K are shaded. (Left) the analyses of Test run and (Right) those of Control run. (Top) at 850mb and (Bottom) at 700mb.

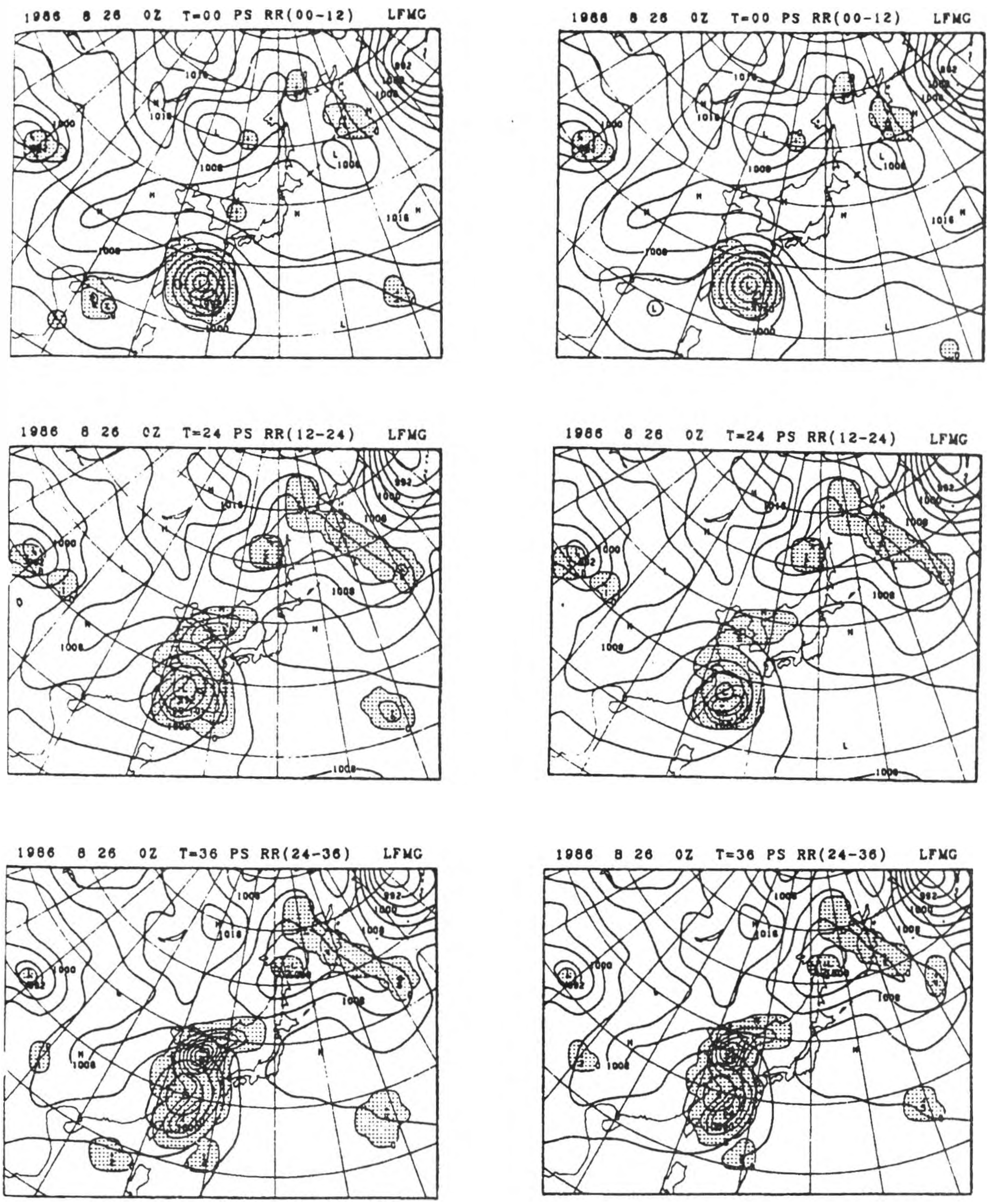

Figure 18 Comparison of the forecasted sea level pressure and precipitation by Test run (Left column) and Control run(Right column). The contour interval of PS is 4mb. Precipitation areas are shaded and the contour interval of the accumulated precipitaions is 5mm/6hour. (Top) Initial Ps and precipitation during 0 to 12 forecast hours, (Middle) Ps at 24 hour forecast and precipitation during 12 to 24 forecast hours, and (Bottom) Ps at 36 hour forecast and precipitation during 24 to 36 forecast hours.

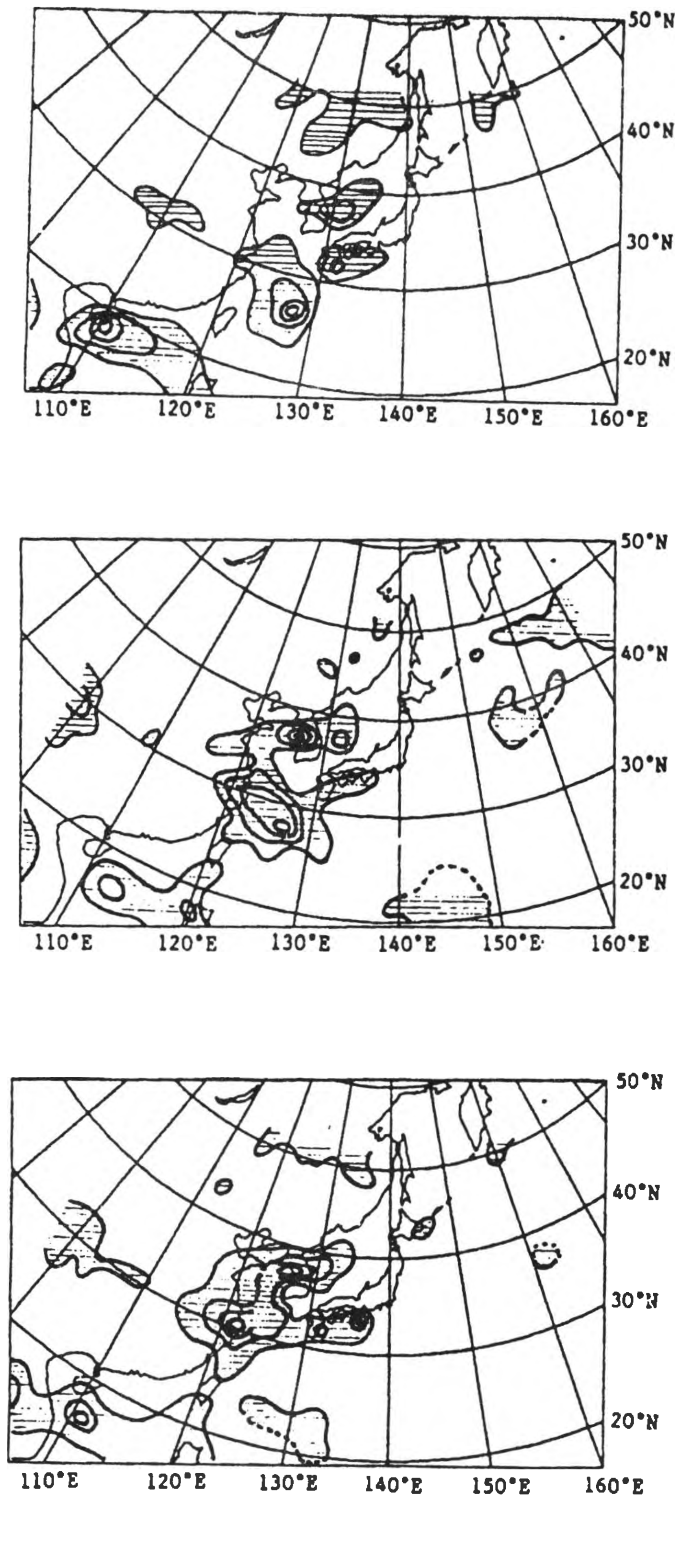

Figure 19 12hour total precipitations from SYNOP and SHIP observations. (Top) for the first 12 hour (from 0000UTC 26 August to 1200UTC 26), (Middle) for the second 12 hour period (from 1200UTC 26 to 0000UTC 27), and (Bottom) for the third 12 hour period (from 0000UTC 27 to 1200UTC 27).

JMA/NPD TECHNICAL REPORTS

No.1 Long-time Integrations of Numerical Prediction Model (A. Sumi and K. Tamiya: 1985)

No.2 Monthly Verifications of JMA Forecast Models Performance Summary During 1984 (T. Nakayama: 1985)

No.3 A Spectral Limited Area Model with Time Dependent Lateral Boundary Condition and Its Application to a Multi-level Primitive Equation Model (Y. Tatsumi: 1985)

No.4 Mean Forecast Error and Diabatic Heatings of the Operational JMA Spectral Model (K. Tada and M. Kanamitsu: 1985)

NO.5 An Objective Analysis of Sea Surface Temperature (A. Baba: 1986)

No.6 Performance of Typhoon Movement Prediction Model with Cumulus Parameterization (T. Iwasaki, H. Nakano and M. Sugi: 1986)

No.7 Monthly Verifications of Numerical Predictions at JMA During 1985 (K. Kuma: 1986)

No.8 On an Influence of Forecast-Analysis Cycle on the Forecast Performance (T. Kitade, K. Yanagino, N. Sato and M. Oozeki: 1987)

No.9 A Forecast Experiment on the Large Scale Features of the Baiu Front (H. Nakamura and N. Hasegawa: 1987)

No.10 An Improvement of the Vertical Interpolation Method for the Initial Field of a Regional Model (H. Yokoyama and A. Segami: 1987)

No.11 Application of the Second-Order Turbulence Closure Scheme to JMA's Regional Model (A. Segami: 1987)

No.12 An Intercomparison Study of Gloval Forecasts with JMA and BMRC Models (T. Hiraki: 1987)

No.13 A Dynamic Assimilation Method for a Mesoscale Model Using Observed Raifall Rates (M. Ueno, R. Taira and T. Kudo: 1987)

No.14 One-month Forecast Experiments with a Correction of Systematic Errors of the Zonal Mean Temperature during the Time Integration (T. Tsuyuki and M. Kanamitsu: 1987)

No.15 A Forecast Experiment of an Intense Rainstorm on the Baiu Front over Western Japan (K. Kurihara, M. Ueno and N. Miura: 1987)

No.16 Improvement of the Estimation Method of Moisture Data from Satellite Cloud Soundings (A. Baba: 1987)

Annex XI

New Satellite Products for Numerical Weather Prediction

CGMS-XVIII USA WP-18
Prepared by USA
Agenda Item J

NEW PRODUCTS FOR NWP

Summary and Purpose of Document

Following the discussion at CGMS-XVII(Item 17.19), on the perceived requirements for new operational satellite products (at that time the only product suggested by the USA was some form of outgoing long-wave radiation), the NMC has taken a more complete look at what new products would serve nwp purposes to advantage. This paper describes the results of such an exercise.

Action Proposed

Suggested New Satellite Products for NWP

At present, the clouds in the NMC numerical prediction models are used only to modify radiative fluxes through processes of reflection, absorption, emission, and scattering. Thus, they interact with the forecast model entirely through layer radiative heating rates and surface radiative fluxes. The clouds carried by the models are specified by algorithms involving the dynamical variables of the models, and thus are not explicitly predicted by the model equations. In the future, NMC plans to explicitly predict clouds by adding a cloud-water variable. These clouds will then interact more realistically with the hydrological and radiative processes, which, in turn, will allow a more proper modelling of cloud radiative properties.

At that future time, the NMC will require 'real-time', i.e. operational cloud and radiative budget observations for a variety of reasons. First, they will allow validation of the current cloud parameterization schemes by providing an observed nephanalysis. Second, they will allow a tuning of the interactive cloud algorithms and the development of newer, more sophisticated cloud representation schemes. Finally, these operational products will be used to initialize the input data to the forecast models. For the current (i.e. diagnosed) cloud schemes, the products might be used to infer relative humidity in data-sparse areas. For the (future) explicit schemes, values of cloud water content would be necessary.

The following list.of the NMC's requirements for cloud, ozone, and radiative budget data is based upon the preceding discussion of current and future forecast models. The list has been drawn up with full recognition that several data and/or accuracy requirements await future satellite technology: they have been included for planning purposes.

The companion Working Paper to the present one gives a list of NOAA-K,L,M products planned by NESDIS. Those of this product list that satisfy the nwp requirements, as perceived at the present time, are indicated by an -*.

DATA REQUIRED:

1. CLOUD AMOUNT- Total cloud cover up to 5 non-obscured layers. (Accurate to ?5%) [Total amount *]

2. CLOUD TOP- Needed to place verifying cloud in proper model layers.
   a.*Cloud top temperature (Ebb to 3 deg K)
   b.*Estimates of top height or pressure.
   c. Data to include mean and variance (on resolution specified-see below) of cloud top temperature. [To be used for estimating tropical precipitation rates. A 4-category quantitative global precipitation estimate will be supplied for NOAA-K,L,M *]

3.*CLOUD TYPE- Possibly a system designating deep convective, thin cirrus, shallow convective, stratus, etc. cloud. *Later, an estimate of cloud-water/ice content.

4. RADIATION DATA-
   a.*Broad-band, outgoing longwave (to 10 watts per meter squared)
   b.*Broad-band outgoing shortwave (also to 10 w/m2)
   c. Surface, broad-band longwave (10 w/m2)
   d. Surface, broad-band shortwave (")
   e. Estimates of layer radiative heating rates in atmospheric layers. (accuracy, 0.1 K/day ??)

5.*OZONE- total column and profile

II. CHARACTERISTICS OF DATA:

1. Horizontal resolution. Global, on the order of 50km.
2. Synoptic data. instantaneous cloud/radiation data within three hours of 0000 and 1200 UTC. (expanded to include 0600 and 1800 UTC in future).
3. Time availability- definition of 'real-time'. For diagnostic purposes, availability should be within 24 hours. For data used in initializing the models, availability should be within 1-2 hours of synoptic time.

A more complete version of this paper, with specific comments on the NMC's current and near-future models, exists as an internal memo document. It was produced as a result of joint meetings between NMC modelling personnel and NESDIS personnel.

New NESDIS Products from NOAA-K, L and M

CGMS-XVIII USA WP-19
Prepared by USA
Agenda Item J
I.4

NESDIS NEW PRODUCTS FOR NOAA KLM

Summary and Purpose of Document

The document contains the NESDIS approved NOAA KLM product list. The paper also discusses aspects of the major product changes from the current product list.

Action Proposed

NESDIS New Products from NOAA KLM
Patricia Mulligan, NOAA/NESDIS et. al.[1]

When NOAA K is launched it will be carrying a new twenty channel microwave sounding instrument, the Advanced Microwave Sounding Unit (AMSU), and an improved Advanced Very High Resolution Radiometer (AVHRR) with a 1.6 um channel, time shared with the present channel 3. At that same time an entirely redesigned product generation system will have been brought on line. Several new products will be generated in this time frame, and many others will be improved. Product changes will result from sensor changes, improved science, software upgrades, and even changes in the preprocessing system such as new calibration techniques.

Appended to this paper is the NESDIS NOAA KLM Product List. Products designated "primary" are approved, and funded, for development;. "secondary" products are likely candidates for development in the future. On the system level, much of the new software will be installed by late summer in 1991, and will be used to process data from the current NOAA polar satellites. Software specific to the new microwave data will be implemented at the launch of NOAA K. Several of the NOAA KLM product changes are discussed in further detail below. Additional documentation is available on request on the science foundation of the products and on the software system design.

Atmospheric Sounding Products

The NOAA KLM System will be capable of delivering a slightly increased quantity of improved products in late 1991, and both new and improved products at a higher quantity in the mid-nineties (dependent upon the actual launch of NOAA-K). The Microwave Sounding Unit (MSU) and Stratospheric Sounding Unit (SSU) instruments are replaced by the AMSU, but the existing High Resolution Infrared Sounder (HIRS) instrument will be retained. New science techniques will be applied to both microwave and infrared data.

Sounding system changes are being implemented in two phases in order to separate in time the check out of new software, new science, and a new sensor's data. The first phase, "System '90 will incorporate the AVHRR Global Area Coverage (GAC) data at the HIRS Field of View (Fov) and will use improved infrared science to generate the same sounding products as the existing TOVS system.

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[1] B. Banks, H. Drahos, N. Shellman, N. Grody, J. Sapper, D. McGinnis, H. Jacobowitz, M. Weaks, L. Stowe, NOAA/NESDIS, Suitland, MD; and R. Ferraro, S.M. Systems and Research Corp., Landover MD

Improvements are anticipated in the products due to better cloud identification and clearing using AVHRR data and improved science techniques (N* improvements), and due to the repositioning of the global limb correction to just prior to the retrieval process. Additionally, the third path products should benefit because of the improved coefficient generation system that utilizes cloudy retrievals for the first time. The retrieval technique will retain the physical solution now used in TOVS, but a different first guess may be incorporated. A small increase in the number of retrievals generated is possible because of more efficient use of all data, and science improvements. A by-product of the System '90 architecture will be horizontal gradient information. User demand for these fields may result in their being designated as products in the future. Considerably more quality control (Q/C) of all science processes and trend analysis of specific parameters are also being incorporated into the system. There are no plans at this time to change the user interface through the implementation of System '90.

The second phase, "System '92" will be implemented at the time the NOAA-K spacecraft is launched. AMSU data will permit the generation of some completely new products such as cloud liquid water and cloud composition. All existing products will continue, except that considerably more accuracy in both temperature and water vapor profiles is anticipated especially in the tropospheric cloudy regions due to the greatly increased horizontal and vertical resolution of the AMSU instrument. All previous infrared science will be retained in the new system. Unfortunately, because the AMSU does not view as high in the atmosphere as the SSU, the height of useful retrieval products will fall from 1mb to around 2mb (45 km), for the data from NOAA K's sensor. However, additional microwave channels peaking higher in the atmosphere will be included as soon as possible on following satellites. The product resolution will increase from about 80 km to 50 km at nadir in the horizontal with a corresponding increase in the number of products available (before filtering) to about a quarter million per spacecraft per day. This represents almost an order of magnitude increase in products and therefore substantial filtering (reductions of products in uneventful meteorological areas, where redundancy can be eliminated and bad or dubious quality products are removed), and renovation of the user interface software (format and content) is planned between the implementation of System '90 and System '92.

Image Products

New Products - Global polar stereographic masters will be generated from selected channels of instrument data. The AMSU sensor has two components, AMSU-A containing channel 1-15 with an FOV approximately 50 km, and AMSU-B containing channels 16-20 with an FOV of approximately 15 km. AMSU channels 1,2,3,4,5,15, 16 and 17 will be mapped. The map resolution will be 47.6km and 23.8km for the AMSU-A and AMSU-B respectively at the 60 degree north and south latititudes with a prime longitude of 80 west. In addition to the instrument data; the scan time, scan angle, solar zenith angle and the satellite azimuth angle will be mapped. These products will be produced daily and used to derive other environmental products such as quantitative precipitation, snow cover and ice products.

Improved Products - Global polar stereographic maps generated from AVHRR channels 1 and 4 are produced as part of the current daily routine operation. For NOAA KLM all six AVHRR channels will be mapped to a polar stereographic projection plus the scan time, scan angle, solar zenith angle and the satellite azimuth angle. These maps will have a resolution of 23.8 km at the 60 degree north and south latitudes and a prime longitude of 80 west. The data will be mapped as 8 bit bytes. The daily maps are expected to be archived by SDSD. They will also be used to derive other products such as a quantitative precipitaion, snow cover, and global vegetation index products.

Precipitation and Sea Ice

As part of System '92, the AMSU data will be gridded to the master maps at two resolutions: 1/8 mesh for the AMSU-A window channels and 1/16 mesh for the AMSU-B window channels. These will be used to generate products of precipitation intensity (both resolutions), and sea-ice type and concentration. Other products which could be generated from this data might in the future include:

1. Rain areal coverage (percent)
2. Snow cover water equivalent (mm)
3. Oceanic cloud liquid water (kg/m**2)
4. Oceanic total precipitable water (kg/m**2)
5. Global surface type

Snow Cover

The new near-infrared (1.6 um) channel on the AVHRR will permit the separation of clouds from snow. At this wavelength, cloud reflectivity (except possibly cirrus) remains bright (white), but snow reflectivity becomes very low (black). This new operational capability will further enhance existing procedures by aiding in the mapping of snow in frequently cloudy areas. An algorithm to provide this improvement is in final testing. Once in place, the accuracy of snow cover maps should show noticeable improvement. The new technique will essentially automate a product that now requires extensive human interaction in its creation. Snow cover will later be generated from master maps of AMSU data.

Earth Radiation Budget Products

The Earth's radiation budget has been derived from narrowband channels on the NOAA operational satellites since 1974, but in the era of the NOAA K, L, and M satellites (hereby referred to as KLM) or earlier, a number of positive changes will take place. These changes cover not only how the data will be processed to generate the standard products, but the addition of new products that will greatly enhance our ability to interpret the data. The scientific community is being greatly challenged to come up with answers as to how and why our climate is changing in response to sizeable changes in the carbon dioxide concentrations in our atmosphere, as well as what are the long term effects of ozone depletion. The role that clouds play must be understood, which requires us to study the interactions of the clouds with atmospheric radiation.

For years the data system for generating the Earth radiation budget products was closely tied to the data system which extracts the sea surface temperature, since a lot of the input data was used by both. Now, a new stand-alone data system is being developed for the KLM era. Some of the major improvements will be in its error-checking capabilities, its well-documented code, and the increase in efficiency of processing. Modules are being designed to have a single purpose so that their unique relationship to other modules is easily defined. This will permit easy modification of the code should a major change to an algorithm be required.

While the current data system uses one channel of AVHRR data to estimate the outgoing longwave radiation (OLR), the new system will utilize at least four channels of the HIRS/3 instrument. This has been demonstrated to significantly reduce the RMS error from that obtained with the AVHRR channel, as well as greatly reducing regional bias errors. The OLR will continue to be generated from the AVHRR as well for an unspecified period of time because of the requirements of a number of users of the data. Although not as accurate as that derived from the HIRS/3, some utilize the data as an index of change. A sudden shift to that produced from the AVHRR could be sufficiently approximated from the OLR generated from HIRS/3. Histograms of the OLR and the shortwave fluxes (SW) will continue to be produced from the AVHRR, but a number of changes are planned. While currently three-level histograms are produced separately for the OLR and SW, the new system will generate two-dimensional (5X5 or 6X6) histograms of OLR and SW.

Although improvement to the OLR products comes primarily from use of the HIRS/3 instrument, improvement to the SW is derived principally from improvements to the algorithms. Recently, the anisotropy of the radiation was taken into account by the implementation of angular distribution models. These models are applied to the "so-called" isotropic albedos. Originally, the albedo was that computed from channel 1. Now, a broadband estimate of this albedo is made from channels 1 and 2 using a linear model derived from an analysis of broadband and AVHRR radiances. Further improvements are expected soon as a result of simultaneous observations of broadband (ERBE) and narrowband (AVHRR) radiances on the NOAA-9 satellite.

While much of the discussion above was devoted to the improvement of current products, a number of new, not yet approved, products might be anticipated. Already, on an experimental basis, statistical products derived from the OLR and SW fluxes are being produced and studied. One of these is the spatial standard deviation, which is obtained by computing the square root of the monthly mean variance for each grid point. Another is the temporal standard deviation obtained by computing, for each grid point, the standard deviation of the daily values in a month. These products are expected to enhance our interpretation of the radiation budget. Other products that have been proposed are the clear-sky flux (LW and SW) and the cloud forcing. These products will be useful in obtaining the surface radiation budget and understanding the interaction of the radiation with clouds.

Ocean-Feature Products

A new ocean product is planned for the NOAA KLM era - high resolution mapped sea surface temperature (SST) images. These SST images will be generated by software within Products Systems Branch (PSB) using HRPT/LAC digital data. The software will automatically calibrate, map and calculate SST from digital HRPT/LAC data for selected ocean regions on a pass-by-pass basis. Besides SST images, several other mapped images and satellite parameters are generated which can be used for oceanographic purposes as well as other applications. The mapped images will be transferred electronically to NOAA's Ocean Products Center (OPC) where they will be interactively analyzed on the PC-based Interactive Digital Image Display and Analysis System (IDIDAS) to produce ocean feature products. The mapping software is expected to be operational by mid-1990.

Also under development for the NOAA KLM era are interactive software programs for the IDIDAS system which detect and mask clouds on HRPT/LAC based SST images. These programs were adapted from the cloud tests originally developed by Dr. Paul McClain for the GAC-based multichannel SST (MCSST) system. Testing of the interactive tests will begin in late 1989; operational use is expected in early 1990. Several of the programs are expected to be incorporated into the automated SST mapping routine in PSB by the middle of 1991.

Aerosol Products*

*Aerosol Products are currently listed as secondary products on the NOAA KLM Product List. However, it is highly likely that one or more of those products will advance from experimental to operational status on the Service's current product list before the launch of NOAA K. The equivalent aerosol product on the NOAA KLM list would presumably be designated primary at that time.

Aerosols are tiny particles, usually less than one micron in radius, which are suspended in the atmosphere. The number of particles, their size distribution and absorptivity are of considerable interest from the aspect of satellite remote sensing and detection of global climate change. Remote sensing coupled with computer modeling of the effects of aerosols on reflected sunlight can provide some of this information. The radiance of visible and near-infrared sunlight reflected from a cloud-free ocean surface contains information about these aerosol properties.

The current aerosol system incorporated in the Oceanographic Products System software uses the DAVE (1972) radiative transfer model with an inverse power law aerosol size distribution and different indicies of refraction to compute the radiance of reflected sunlight at appropriate values of solar and satellite zenith angles, solar-satellite azimuth angle, wavelength, and total number of aerosol particles. The radiative transfer theory uses the physics of Mie and Rayleight extinction, and absorption by ozone, water vapor, and carbon dioxide and assumes a Lambertian ocean surface. Radiance lookup tables are created as a function of the independent variables for channel 2 of AVHRR.

For NOAA-K these tables will be produced for all three reflectance channels of AVHRR. If only one channel is used, as is currently done in the NOAA-11 algorithm, only the total number of particles in the atmospheric column can be determined. Later, AVHRR channels 1 and 2 will be used to determine the effective size distribution of the particles. Further advances will use channels 1, 2, and 3a to add a measurement of an absorption parameter to the two parameters measured by system 90. Other parameters will be computed and mapped from these retrieved parameters. This will provide global aerosol products in contour map form. The following is a list of these proposed retrieved and derived parameters. The first three are the retrieved parameters.

- Total number of Particles
- Size Distribution Parameter
- Absorption Parameter
- Total Optical Thickness @ 0.38 UM
- Angstrom Beta Parameter
- Linke Turbidity Factor
- Chemical Species (e.g. Smoke, Dust)
- Total Aerosol Mass
- Albedo of Single Scattering
- MCSST Aerosol Correction
- HIRS Sounding Aerosol Correction

TABLE V-2. NOAA-K, L, M PRODUCTS LIST

I. PRIMARY

OBSERVATION	ACCURACY	HORIZONTAL RESOLUTION	VERTICAL RESOLUTION	SENSORS	COVERAGE	FREQUENCY
A. CLOUD PARAMETERS						
TATZ01 Cloud Liquid Water (non-precipitating clouds)	±0.1 milimeter	50 km at nadir increasing with scan angle	N/A	AMSU	GLOBAL	Every Orbit
B. Mapped and Gridded Data						
TBTZ01 Polar Stereographic Mapped Mosaics Visible, Day IR, Night IR	±5 km	1024x1024 Mesh/Hemishere	N/A	AVHRR/3	GLOBAL	Daily
TBTZ02 Mercator Mapped Mosaics -Visible, Day IR, Night IR	±5 km	Equatorial Strip 360 deg Longitude 80 deg latitude	N/A N/A	AVHRR/3	GLOBAL	Daily (Shared Processing)
TBTZ03 Stretched Gridded Single Orbit Visible, Day IR, Night IR	±5 km	4 km	N/A	AVHRR/3	GLOBAL	Every Orbit (Shared Processing)
TBTZ04 Polar Stereographic AMSU Mapped Mosaics, Channels 16 and 17		1024 X 1024 (See Appendix D)	N/A	AMSU	GLOBAL	Daily
TBTZ05 Polar Stereographic Full Resolution Mapped Images	1.4 km 5.8 km	8192 X 8192 4096 X 4096	N/A	AVHRR/3	LOCAL AREA	Daily
C. ATMOSPHERIC PARAMETERS						
TCTZ01 Vertical Temperature Profiles (Point Temperatures)	Surface -700mb, ±2.5 700mb-Trop., ±2.0 Trop.-2mb, ±2.5 2mb-0.1mb, ±3.0 OVER WATER Surface-Trop., ±2.0	50 km at nadir increasing with scan angle	Minimum of 40 levels; sfc-0.1 mb	AMSU/HIRS/3 AVHRR/3	GLOBAL	Every Orbit

OBSERVATION	ACCURACY	HORIZONTAL RESOLUTION	VERTICAL RESOLUTION	SENSORS	COVERAGE	FREQUENCY
C. ATMOSPHERIC PARAMETERS (CONTINUED)						
TCTZ02 Vertical Water Vapor Profiles (g/Kg)	Surface -700 mb, ± 2.5 700mb-Trop., ± 2.0 Trop.-2mb, ± 2.5 2mb-0.1mb, ±3.0 OVER WATER Surface-Trop., ± 2.0 Trop. -2mb ± 2.5 2mb-0.1 mb ± 3.0	50 km at nadir increasing with scan angle	Minimum of 15 levels; sfc-0.1 mb	AMSU/HIRS/3 AVHRR/3	GLOBAL	Every Orbit
TCTZa2 Total Precipitable Water (cm)	±0.6 cm over land ±0.3 cm over water	50 km at nadir increasing with scan angle	N/A	AMSU/HIRS/3 AVHRR/3	GLOBAL	Every Orbit
TCTZb2 Layer Precipitable Water (mm)	±20% - Land ±10% - Water	50 km at nadir increasing with scan angle	3 layers sfc-300 mb	AMSU/HIRS/3 AVHRR/3	GLOBAL	Every Orbit
TCTZ03 Quantitative Precipitation (None, Light, Medium, Heavy)	4 Categories (TBD)	15-30 km	N/A	AMSU/AVHRR	GLOBAL	6-12 Hours (Shared Processing)
TCTZ04 Clear Equivalent Blackbody Temperatures for 20 HIRS, 20 AMSU and 3 AVHRR Channels (deg K)	± 1 Deg K	50 km at nadir increasing with angle	N/A	AMSU/HIRS/3 AVHRR/3	GLOBAL	Every Orbit
TCTZa4 Thickness Values (M) Byproduct of I.4C	Equivalent to accuracy goal for Layer Mean Virtual	50 km at nadir increasing with angle	Maximum of 20 layers sfc - 0.4 mb	AMSU/HIRS/3 AVHRR/3	GLOBAL	Every Orbit

OBSERVATION	ACCURACY	HORIZONTAL RESOLUTION
C. ATMOSPHERIC PARAMETERS (CONTINUED)		
TCTZ05 Layer Mean Virtual Temperatures (Deg. K)	0.25 Deg K more accurate than Vertical Temperature profile layers given under 1C	50 km at nadir increasing with angle
D. OCEAN SURFACE PARAMETERS		
TDTZ01 Global SST Observations	0.5 Degree C.	8 km spaced 8-25 km Apart
TDTZ02 Local SST Observations	0.5 Degree C.	2 km spaced 2-11 km Apart
TDTZ03 Monthly Mean SST	0.5 Degree C.	1.0 Degree Lat/Long
TDTZ04 Semi-Monthly Mean SST	0.5 Degree C.	1.0 Degree Lat/Long
TDTZ05 Global SST	0.5 Degree C.	0.5 Degree Lat/Long
TDTZ06 Regional SST	0.5 Degree C.	1/16 - 1/32 Degree Lat/Long
TDTZ07 Local SST	0.5 Degree C.	1 - 4 km
TDTZ08 Ocean-Feature	1 km location	1 - 4 km

* Produced by Ocean Products Center

VERTICAL RESOLUTION	SENSORS	COVERAGE	FREQUENCY
Maximum of 20 layers sfc - 0.4 mb	AMSU/HIRS/3 AVHRR/3	GLOBAL	Every Orbit
N/A	AVHRR/3	GLOBAL	Every 6 Hours (Shared Processing)
N/A	AVHRR/3	U.S. coastal waters and selected areas	Every 6 Hours
N/A	AVHRR/3	GLOBAL 75 S - 80 N	Monthly
N/A	AVHRR/3	GLOBAL 75 S - 80 N	Twice/Month
N/A	AVHRR/3	GLOBAL 75 S - 80 N	Twice/Week
N/A	AVHRR/3	U.S. coastal waters and selected areas	Twice/Week
N/A	AVHRR/3	U.S. coastal waters	Twice/Week
N/A	AVHRR/3	U.S. coastal	Twice/Week

TABLE V-2. NOAA-K, L, M PRODUCTS LIST (CONTINUED)

I. PRIMARY

OBSERVATION	ACCURACY	HORIZONTAL RESOLUTION	VERTICAL RESOLUTION	SENSORS	COVERAGE	FREQUENCY
TDIG09 Edge	1 km	Line Position	N/A	AVHRR/3 AMSU	GLOBAL	Weekly (Shared Processing)
TDIG10 Cover	$\pm$5%	100 km^2	N/A	AVHRR/3 AMSU	GLOBAL	Weekly (Shared Processing)
TDIG11 Type: New, First Year, Multiyear, Melting	(TBD)	1000 km^2	N/A	AVHRR/3 AMSU	GLOBAL	Daily (Shared Processing)
TJIZ02 Snow Cover Area	$\pm$ 10%	25 km	N/A	AVHRR/3 AMSU	GLOBAL	Weekly
F. DAILY RADIATION BUDGET						
TFTZ01 Albedo	TBD	2.5 Degree Mercator & 125x125 Polar Stereo.	N/A	AVHRR/3	GLOBAL	Daily
TFTZ02 Daytime Outgoing Longwave Radiation	TBD	2.5 degree Mercator & 125x125 Polar Stereo.	N/A	AVHRR/3	GLOBAL	Daily
TFTZ03 Nighttime Outgoing Longwave Radiation	TBD	2.5 degree Mercator & 125x125 Polar Stereo.	N/A	AVHRR/3	GLOBAL	Daily
TFTZ04 Daily Average Outgoing Longwave Radiation	TBD	2.5 degree Mercator & 125x125 Polar Stereo.	N/A	AVHRR/3	GLOBAL	Daily
TFTZ05 Available Solar Energy	TBD	2.5 degree Mercator & 125x125 Polar Stereo.	N/A	AVHRR/3	GLOBAL	Daily

I. PRIMARY

OBSERVATION	ACCURACY	HORIZONTAL RESOLUTION	VERTICAL RESOLUTION
F. DAILY RADIATION BUDGET (CONTINUED)			
TFTZ06 Absorbed Solar Radiation	TBD	2.5 degree Mercator & 125x125 Polar Stereo.	N/A
TFTZ07 Net Radiation	TBD	2.5 degree Mercator & 125x125 Polar Stereo.	N/A
G. MONTLY MEAN RADIATION BUDGET			
TGTZ01 Daytime Outgoing LongwaveRradiation	5.0 w/m^2	2.5 degree Mercator & 125x125 Polar Stereo.	N/A
TGTZ02 Nighttime Outgoing Longwave Radiation	5.0 w/m^2	2.5 degree Mercator & 125x125 Polar Stereo.	N/A
TGTZ03 Absorbed Solar Energy	5.0 w/m^2	2.5 degree Mercator & 125x125 Polar Stereo.	N/A
TGTZ04 Available Solar Energy	5.0 w/m^2	2.5 degree Mercator & 125x125 Polar Stereo	N/A
TGTZ05 Albedo	0.005%	2.5 degree Mercator & 125x125 Polar Stereo.	N/A
TGTZ06 Daily Averaged Outgoing Longwave Radiation	5.0 w/m^2	2.5 degree Mercator & 125x125 Polar Stereo.	N/A
TGTZ07 Net Radiation	7.0 w/m^2	2.5 degree Mercator & 125x125 Polar Stereo.	N/A

SENSORS	COVERAGE	FREQUENCY
AVHRR/3	GLOBAL	Daily
AVHRR/3	GLOBAL	Daily
AVHRR/3	GLOBAL	Monthly
AVHRR/3	GLOBAL	Monthly
AVHRR/3	GLOBAL	Monthly
AVHRR/3	GLOBAL	Monthly
AVHRR/3	GLOBAL	Monthly
AVHRR/3	GLOBAL	Monthly
AVHRR/3	GLOBAL	Monthly

TABLE V-2. NOAA-K, L, M PRODUCTS LIST (CONTINUED)

I. PRIMARY

OBSERVATION	ACCURACY	HORIZONTAL RESOLUTION	VERTICAL RESOLUTION	SENSORS	COVERAGE	FREQUENCY
I. OZONE						
TITZ01 Total Ozone (Dobson Units)	±15 % Tropical ±30 % Polar	50 km at nadir increasing with scan angle	N/A	HIRS/3	GLOBAL	Every Orbit
TITZ02 Total Ozone (Dobson Units)	± 1.0%	200 km sub-satellite	N/A	SBUV/2	GLOBAL	Daily
TITZ03 Level Ozone (Mixing Ratio)	± 5%	200 km sub-satellite	16 levels	SBUV/2	GLOBAL	Daily
TITZ04 Layer Ozone (Dobson Units)	± 5%	200 km sub-satellite	11 layers	SBUV/2	GLOBAL	Daily
J. Land Surface Parameters	TBD	15 km	N/A	AVHRR/3	GLOBAL	Daily
TJTZ01 Vegetation Index						
TJTZ02 Snow Cover Area	+10%	25 km	N/A	AVHRR/3 AMSU	GLOBAL	Weekly

TABLE V-2. NOAA-K, L, M PRODUCTS LIST
II. SECONDARY

OBSERVATION	ACCURACY	HORIZONTAL RESOLUTION	VERTICAL RESOLUTION	SENSORS	COVERAGE	FREQUENCY
A. CLOUD PARAMETERS						
TATZ02 Cloud Top Temperature (Deg K)	1.0-5.0 Deg K increasing with decreasing cloud amount	50 km at nadir increasing with scan angle	N/A	AVHRR/3 HIRS/3 AMSU	GLOBAL	Every Orbit
TATZ03 Cloud Top Pressure (mb)	15-60 mb increasing with decreasing cloud amount	50 km at nadir increasing with scan angle	N/A	HIRS/3 AVHRR/3 AMSU	GLOBAL	Every Orbit
TAZ204 Cloud Amount (%)	±10% increasing with decreasing cloud amount	50 km at nadir increasing with scan angle	N/A	AVHRR/3 AMSU HIRS/3	GLOBAL	Every Orbit
TATZ05 Cloud Composition (Type)	TBD	50 km at nadir increasing with scan angle	N/A	AVHRR/3 AMSU	GLOBAL	Every Orbit
C. ATMOSPHERIC PARAMETERS						
TCTZ06 Tropopause Temperature (Deg K)	±1.5 Deg K - 2.5 Deg K	50 km at nadir increasing with scan angle	N/A	AMSU/HIRS/3 AVHRR/3	GLOBAL	Every Orbit
TCT207 Tropopause Pressure (mb)	±40 mb	50 km at nadir increasing with scan	N/A	AMSU/HIRS/3 AVHRR/3	GLOBAL	Every Orbit

TABLE V-2. NOAA-K, L, M PRODUCTS LIST (CONTINUED)
II. SECONDARY

OBSERVATION	ACCURACY	HORIZONTAL RESOLUTION	VERTICAL RESOLUTION	SENSORS	COVERAGE	FREQUENCY
K. AEROSOL						
TKTZ01 Optical Depth at 0.5 Microns	±0.02%	50 km	N/A	AVHRR/3	GLOBAL (Ocean Only)	7 Days
TKTZ02 Size Distribution	TBD	50 km 125x125 Polar Stereo.	N/A	AVHRR/3	GLOBAL (Ocean Only)	7 Days

WMO Letter to its Members Concerning the Allocation of Frequencies to Data Collection Services of Meteorological Satellites

CGMS-XVIII WMO WP.7
Prepared by WMO
Agenda item: L.1

Allocation of frequencies to the DCS

CBS IX (January-February 1988) requested its Working Group on the GTS to develop, in co-ordination with CGMS, a proposal for submission to the next ITU Administrative Conference concerned, aimed at improving the protection of the DCS against harmful interferences. The Study Group on Communication Techniques and Protocols reviewed this matter at its fourth session (Geneva, 29 May-2 June 1989), and, based on its outcome, the WMO Secretariat sent a letter to WMO Members with a view to:

(a) including the allocation in the band 400.15-406 MHz in the agenda of the next world Administrative Radio Conference (1992);

(b) initiating the preparations for a consolidated proposal through co-ordination between WMO Members, CGMS, CIMO and CBS.

A copy of the letter is attached herewith for information.

(WWW 13)

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WORLD METEOROLOGICAL ORGANIZATIC

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SECRÉTARIAT
GENÈVE - Suisse

41, Giuseppe-Motta
Case postale N° 23
CH - 1211 Genève

No. W/SY/T3.1

GENEVA, 8 September 1989

Annexes: 2

Subject : Allocation of frequencies to data collection services of meteorological satellites

Action required: (a) Contact your national telecommunication administrations for inclusion of the allocation to the Meteorological Satellite Service in the band 400.15-406 MHz, in the agenda at the next World Administrative Radio Conference, and keep the WMO Secretariat informed of any development

(b) Send your preliminary views and comments on draft proposals in Annexes I and II

Dear Sir/Madam,

As requested by CBS at its ninth session (Geneva, January-February 1988), the WG-GTS/Study Group on Communication Techniques and Protocols reviewed, at its fourth session (Geneva, 29 May-2 June 1989), the allocation of frequencies to the data-collection services operated through geostationary meteorological satellites, with a view to improving its protection against harmful interferences.

The Study Group agreed that a necessary and basic step would be to upgrade the "secondary service" allocation, as attributed in the present Radio Regulations of ITU, to a "primary service" allocation. The necessary steps for the consideration of any change in the present Radio Regulations concerning the Meteorological Satellite Service should be the following:

To Permanent Representatives (or Directors of Meteorological or Hydrometeorological Services) of Members of WMO (PR-4393)

cc: President and vice-president of CBS)
Chairman of CBS Working Group on GTS) (for information)
Director of EUMETSAT)
Chairman of IFRB)

(a) Inclusion of this question in the agenda of the next competent World Administrative Radio Conference (scheduled for 1992), which would be prepared by the ITU Administrative Council, likely in May 1990;

(b) Submission of a proposal to the Radio Conference.

Only telecommunications administrations, Members of ITU, have the right to submit proposals as regards steps (a) and (b) mentioned above. WMO can only submit information documents.

This matter is of vital importance for data collection from DCPs via geostationary meteorological satellites, which plays an increasing role in the WWW system.

I should like, therefore, to invite you to approach your national telecommunication administrations, as a matter of urgency, with a view to convincing them to request the inclusion of the frequency allocation to the Meteorological Satellite Service in the band 400.15-406 MHz, in the agenda of the next World Administrative Radio Conference.

The WG-GTS Study Group prepared a draft proposal for a modified allocation to radiocommunication services for meteorological purposes in the 400.15-406 MHz band, attached herewith (see Annex I). Furthermore, it prepared a draft proposal for an ITU resolution, to be submitted for possible adoption at the next World Administrative Radio Conference (1992), with a view to the organization of frequency monitoring programmes in the band 401-403 MHz to identify unauthorized emissions (see Annex II). I would like to seek your preliminary views and comments on these draft proposals. The final aim is to submit a consolidated proposal for consideration by the CBS extraordinary session in 1990, after appropriate co-ordination with CGMS and CIMO. Meteorological services would then be in a position to submit a unified proposal to their national telecommunication administrations for subsequent action to the ITU World Administrative Radio Conference.

Your kind consideration of this matter would be appreciated.

Yours faithfully,

(G.O.P. Obasi)
Secretary-General

WORLD METEOROLOGICAL ORGANIZATION

W/SY/T3.1, ANNEX I

Draft Proposal for a Modified Frequency Allocation in the 400.15-406 MHz

1. Description of the proposal

400.15 - 401	(Unchanged)
401 - 402	Primary: METEOROLOGICAL-SATELLITE (Earth-to-space) SPACE OPERATION (space-to-Earth) Secondary: Meteorological Aids Earth Exploration-Satellite (Earth-to-space) Fixed Mobile except aeronautical mobile
402 - 403	Primary: METEOROLOGICAL-SATELLITE (Earth-to-space) Secondary: Meteorological Aids Earth Exploration-Satellite (Earth-to-space) Fixed Mobile except aeronautical mobile
403 - 406	(Unchanged)

2. Differences between present status and proposal

In the bands 401-402 MHz and 402-403 MHz, the status of the Meteorological-Satellite (Earth-to-space) and the Meteorological Aids service are changed:

- The Meteorological-Satellite (Earth-to-space) service is allocated the primary status;
- The Meteorological Aids service will have the secondary status instead of the primary status.

It must be underlined that Meteorological Aids remain the only primary service in the frequency band 403-406 MHz.

3. Other desirable changes (for further study)

It should be studied whether it would be feasible to remove the Space Operation service from the band 401-402 MHz, and to remove the Fixed service and the Mobile except aeronautical mobile service from the band 401-403 MHz.

(POOLE 4603)

WORLD METEOROLOGICAL ORGANIZATION

W/SY/T3.1, ANNEX II

DRAFT RESOLUTION

Relating to the protection of the band 401-403 MHz allocated to the Meteorological-Satellite Service

The World Administrative Radio Conference (XXX, 1992),

CONSIDERING:

(a) That the present Conference has allocated the band 401-403 MHz to the Meteorological-Satellite Service (Earth-to-space);

(b) That these bands are widely used for the data collection from data collection platforms using the relay of data by geostationary meteorological satellites;

(c) That the number of the data collection platforms has been increasing for several years and that this system plays an increasing role in the monitoring of the meteorological environment and, in particular, in the World Weather Watch of the World Meteorological Organization;

(d) That several cases of harmful interferences have been reported;

(e) That the technical characteristics of the data collection system using geostationary satellites do not provide any easy way to identify the geographical location of the sources of the interferences;

DECIDES:

To entrust IFRB with the organization of monitoring programmes in the band 401-403 MHz with a view to identifying the source of any unauthorized emission in these bands;

TO URGE THE ADMINISTRATIONS:

(a) To participate in the emission monitoring programmes organized by the IFRB aimed at the identification and positioning of the stations in the other services than the services that are authorized to use these bands;

(b) To take all necessary steps to suppress the interferences.

(POOLE 4603)

Addresses for the Procurement of Archived Data

ADDRESSES FOR PROCURING ARCHIVE DATA

ESA **(specific requests for Meteosat imagery and data tapes)**

METEOSAT EXPLOITATION PROJECT - Data Service,
ESOC,
Robert Bosch Str. 5,
6100 Darmstadt
Federal Republic of Germany

EUMETSAT **(general requests for Meteosat archived material)**

The Director
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INDIA

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JAPAN

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Annex XV

<u>Contact List for Operational Engineering Matters</u>

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Annex XVI

Distribution List for Documents

DISTRIBUTION LIST FOR DOCUMENTS

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Annex XVII

CGMS XVIII Agenda

AGENDA FOR CGMS XVIII, WMO, GENEVA, 13 -17 NOVEMBER 1989

A. PRELIMINARIES

A.1 Introduction

A.2 Election of Chairman

A.3 Drafting Committee

A.4 Adoption of Agenda

A.5 Review of Action Items from Previous CGMS Meetings

A.6 Review of Consolidated Report

A.7 Extension of the Responsibilities of the CGMS

B. REPORT ON STATUS OF SATELLITE SYSTEMS

B.1 EUMETSAT

B.2 India

B.3 Japan

B.4 People's Republic of China

B.5 USA

B.6 USSR

C. REPORT ON FUTURE SATELLITE SYSTEMS

C.1 Geostationary Meteorological Satellite Systems

C.1.1 EUMETSAT
C.1.2 India
C.1.3 Japan
C.1.4 People's Republic of China
C.1.5 USA
C.1.6 USSR

C.2 Polar Meteorological Satellite Systems

C.2.1 EUMETSAT
C.2.2 India
C.2.3 Japan
C.2.4 People's Republic of China
C.2.5 USA
C.2.6 USSR

D. OPERATIONAL CONTINUITY AND RELIABILITY

D.1 Inter-regional planning

D.1.1 Use of Meteosat-3 for Atlantic data coverage
D.1.2 INSAT relay - status report
D.1.3 Upgrade of the GOES-Meteosat relay

D.2 Global planning

D.3 Commonality of standards

E. GEOSTATIONARY SATELLITES AS PART OF WMO PROGRAMS

E.1 World Weather Watch

E.1.1 Staus of planning for the OWSE-Africa
E.1.2 Satellite evaluations

E.2 Other Programs

F. COORDINATION OF DATA COLLECTION

F.1 Status and Problems of IDCS

F.1.1 Japan
F.1.2 USA

F.2 Ships, including ASAP

F.2.1 Japan
F.2.2 WMO

F.3 ASDAR

F.3.1 USA
F.3.2 WMO

F.4 Review of IDCS User's Guide

G. COORDINATION OF DATA DISSEMINATION

G.1 Dissemination via Satellite

G.1.1 High Resolution
G.1.2 Low Resolution (WEFAX)
G.1.3 DCP Data
G.1.4 Digital WEFAX

G.2 Dissemination via GTS

G.3 Other Dissemination