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WMO SATELLITE REPORTS

APPLICATION OF SATELLITE TECHNOLOGY

ANNUAL PROGRESS REPORT

1986

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WMO SATELLITE REPORT

SAT-1 Application of Satellite Technology Annual Progress Report 1983

SAT-2 Satellite Capabilities to 1995 for Meteorology and Operational Hydrology (by David S. Johnson)

SAT-3 Application of Satellite Technology Annual Progress Report 1984

SAT-4 Application of Satellite Technology Annual Progress Report 1985

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W O R L D M E T E O R O L O G I C A L O R G A N I Z A T I O N

APPLICATION OF SATELLITE TECHNOLOGY

ANNUAL PROGRESS REPORT

1986

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INTRODUCTION

The seventh session of the EC Panel of Experts on Satellites (1985) evaluated the Progress Reports on the applications of satellite technology to meteorology and operational hydrology and recommended that it be continued. The panel stressed the importance of the timely distribution of this report.

The purpose of this publication is to acquaint Members concerned with the state of development in satellite applications, as well as the operational uses of satellite data, derived products and services in the meteorological and hydrological services in different countries.

This report includes the applications of satellite technology within three functional areas:

(1) Remote sensing of spectral radiation which can be converted into measurements for meteorological and operational hydrological applications (this includes the data and the derived products such as atmospheric soundings, sea surface temperature, satellite cloud wind, etc.);

(2) Collection of data from in-situ sensors (commonly referred to as the data collection system such as Service-Argos on the NOAA polar-orbiting satellites); and

(3) Transmission of satellite data through a direct broadcast mode (APT and High Resolution Picture Transmission (HRPT) on polar-orbiting satellite; WEFAX, High Resolution Facsimile (HRFAX) and low Resolution Facsimile (LRFAX); Primary Data Utilization Stations (PDUS), and Secondary Data Utilization Station (SDUS) on geostationary meteorological satellites).

The progress reports have the following major subdivisions;

PART I - A brief summary of the major highlights
PART II - Major research and development in the application of satellite data, derived products and services
PART III - Techniques development in the applications of satellite data, derived products and services
PART IV - Systems for satellite applications in operational use in 1986
PART V - Plans for future operational systems for satellite applications to meteorology and operational hydrology
PART VI - Validation and verification of satellite data and derived products used in operations, including performance statistics
PART VII - Other items (references, publications and names of scientist in charge, etc.).

The present report, the fourth in the series, contains 37 contributions received in response to the request made in WMO circular letter S/MS/ECP of 12 November 1986.

SUMMARY

This set of reports for 1986 from 36 Members and the EUMETSAT shows a continued development of satellite data applications to various fields of meteorology and operational hydrology.

Satellite data are now being used operationally for monitoring tropical cyclones, severe meso-scale storms, floods and forest fires, and for derivation of the basic physical parameters of both the atmosphere, such as wind, temperature and moisture, and the surface, such as sea surface temperature, vegetation, ice and snow cover, sea ice, ocean states and albedo. Convective rainfall, monthly river run-off and water balance are successfully determined by using more sophisticated satellite retrieval techniques. These parameters are widely applied to diagnostics, nowcasting, numerical weather prediction and climate studies.

Satellite data bases are being developed in some countries for applications such as monitoring of the El Niño-Southern Oscillation. These data sets are also expected to be used in other studies such as the International Satellite Cloud Climatology Project (ISCCP).

Satellite-based telecommunication continues to increase for operational use among WMO Members. Satellite data collection provides a valuable source of in-situ observation data from isolated meteorological and hydrological stations and from ships, buoys and aircraft. Such data from remote regions also offer ground truth information concerning various meteorological and hydrological parameters for validating information derived from satellite remote sensing.

The number of meteorological satellite ground stations are increasing and some are being upgraded to obtain the high resolution satellite direct broadcast data. Satellite data are handled in a digital format at the high resolution stations, most of which carry on some operations to derive quantitative information from the radiances.

Thus, the current global network of meteorological satellites plays an increasingly important role in observation, data collection and dissemination. Joining the satellite operators of the global network in 1986 was EUMETSAT, the European intergovernmental organization founded by 16 states, which was formally established in June 1986 and has taken over the responsibility of the METEOSAT Operational Programme. Also in 1986, upgrading of the ground data handling system in Japan enabled further improvements of the GMS observation and services within the global network.

ARGENTINA

Servicio Meteorológico Nacional (S.M.N.)

PART I SUMMARY OF THE MAJOR HIGHLIGHTS OF RESEARCH, APPLICATIONS AND OPERATIONAL CHANGES.

1.1 There were no major changes in operational processing of image data during the year.

Data form DCP begins to receiver continuously after the installation of some automatic platforms.

PART II DESCRIPTION OF THE MAJOR RESEARCH AND DEVELOPMENT IN THE APPLICATIONS OF SATELLITE DATA, DERIVED PRODUCTS AND SERVICES.

2.1 The following studies are finished:

- Estimation of flood areas using AVHRR/2 data of TIROS N satellites.
- Monitoring crop areas by NOAA satellite data.
- Vegetation heterogeneity on the Patagonia arid area.

2.2 The following studies are presently being carried out

- Identification and characterization of severe convective systems using very high resolution images.
- Precipitation estimation though cloud system identification using APT images.

2.3 The following studies are suspended because there are some problems in the HRPT processing system.

- Study of the feasibility of solar radiation data beginning with AVHRR data.
- Estimation of snow covered area using very high resolution NOAA images.
- Monitoring of crop and pasture areas using green index from NOAA images.

PART III DESCRIPTION OF TECHNIQUES DEVELOPMENT AND APPLICATIONS OF SATELLITE DATA DERIVED PRODUCTS AND SERVICES.

3.1 The S.M.N. can receive APT data from TIROS-N satellites, as well as METEOR and WEFAX from the GOES satellite.

3.2 The very high resolution station can also receive AVHRR, TOVS and DCS data from NOAA satellites, as well as VISSR and DCP data from the GOES satellite.

3.3 APT and WEFAX data are currently being used for weather analysis and forecasting support activitier at the Buenos Aires Regional Meteorological Center and at other forecasting offices.

3.4 The Buenos Aires RMC can also obtain a stereographic projection of GOES information, every three hours, by means of its very high resolution facilities. In specific weather situations, these can also provide temperature, localization of cloud tops, severe convective system tracking and other data.

3.5 It has been built an archive of NOAA satellite images in the following manner: from July 1984 to October 1985 in digital tapes of 6250 bpi (Atlantic area) with the collaboration of the University of Miami and from October 1985 until now, the information is stored in magnetic tape without process.

PART IV BRIEF DESCRIPTION OF THE SYSTEM FOR SATELLITE APPLICATIONS IN OPERATIONAL USE IN 1986.

4.1 There are three APT stations and one HRPT station, at the S.M.N., presently receiving satellite data:

- Ezeiza (Buenos Aires): APT and WEFAX data are being received since 1970.
- Vicecomodoro Marambio Antartic Meteorological Center. APT and WEFAX data are being received since 1973.
- Comodoro Rivadavia (Chubut): APT data are being received since 1982.
- Villa Ortuzar (Buenos Aires): the HRPT station was installed in 1983 and became operational in 1984.

4.2 It was installed at the Villa Ortuzar HRPT Station one CCT of 1.600/6250 bpi HP 7978. It could expand the system memory of works and archives.

PART V PLANS FOR FUTURE OPERATIONAL SYSTEMS FOR SATELLITE APPLICATIONS TO METEOROLOGY

Plans include:
- Obtention of temperature and humidity profiles from radiance invertion.

PART VI VALIDATION AND VERIFICATION OF SATELLITE DATA AND DERIVED PRODUCTS USED IN OPERATION, INCLUDING PERFORMANCE STATISTICS.

None at the present time.

PART VII OTHER ITEMS

Correspondence should be addressed to

SERVICIO METEOROLOGICO NACIONAL
25 de Mayo 658
1002 Buenos Aires, ARGENTINA.

AUSTRALIA

Bureau of Meteorology

PART I SUMMARY:

There were no significant operational changes in 1986. At times throughout the year there were temporary losses of various forms of data due to failure of systems on GMS, GOES and NOAA satellites.

The data collection system operated through Service Argos was of prime importance for drifting buoy data. Reports from about ninety southern hemisphere drifting buoys were received regularly over the GTS.

Further progress was made with the system for processing direct readout of TOVS from APT reception in Melbourne and Perth and improved displays were introduced. Improvements were also made in systems for enhancing full resolution GMS digital imagery.

On the research side, the integration of McIDAS into the Bureau's data base has been accomplished allowing manipulation and processing of the imagery, grids and observations available to NMC. Work on TOVS has continued with development work being done to produce a robust physical retrieval system for operational use.

PART II RESEARCH AND DEVELOPMENT APPLICATIONS:

Software has been developed to process GMS imagery to obtain cloud statistics (mean cloud top temperature, pixel counts in specified temperature ranges, temperature variability) over circles of specified radius around each grid point on a latitude -longitude grid. The scheme gives objective recognition of imagery characteristics and has important applications in research, particularly for:

(a) Diagnostic studies of the Australian monsoon - The technique has been used to derive composite cloudiness for certain weather events; to determine objectively areas of deep convection for studies of the relationship between such areas and the broadscale flow; and to investigate the movement of tropical cloud zones.

(b) Cloud climatology - A cloud climatology for the Australian region for October to April has been produced from the available data.

(c) Numerical weather prediction studies - A system for improved moisture analyses, using statistical relationships between imagery characteristics and co-located radiosonde moisture profiles, has been developed; and cloud top temperature data are being used to improve model initialisation in the tropics. Case studies have shown a positive impact on analyses in nearly all situations, and an improvement of numerical prediction in some cases.

Further work has been done in the area of interpretation of satellite imagery. A systematic study of the evolutionary characteristics of cloud systems and their relationship to the three dimensional flow has been completed. The nature of the air flow in basic cloud systems; the vorticity comma, the baroclinic leaf, and vortex deformation cloud; were investigated and detailed case studies conducted. A new conceptual model of the three dimensional air flow in a mature, extratropical cyclone has been derived, and a satellite based classification scheme for mature extra-tropical cyclones and cyclogenesis has been proposed.

A project is underway to produce TOVS retrievals in a manually interactive mode on McIDAS using the one-step physical retrieval scheme from Wisconsin. A start has also been made on deriving cloud drift winds from GMS-3 HR-FAX imagery using the McIDAS system.

PART III TECHNIQUES DEVELOPMENT AND APPLICATIONS:

Operational use of McIDAS commenced in Melbourne NMC in July 1986. Most of the effort in techniques development has been directed to refining the capability of the system for handling GMS imagery.

A full range of cloud top temperature enhancements, continuously updated 'movie loops', and integrated displays of imagery, observations, and NWP fields, are all being used to improve techniques for monitoring tropical cyclones, interpreting surface and thickness patterns from imagery, and diagnosing weather elements.

PART IV DESCRIPTION OF OPERATIONAL SYSTEM 1986:

(a) Imagery

The MDUS in Melbourne receives full disk high resolution imagery and selected low resolution sectors from GMS transmissions every three hours. The high resolution imagery is "sectorised" and appropriate areas are transmitted on the facsimile network to forecasting offices around Australia.

Arrangements exist for JMA to provide hourly imagery in severe weather situations such as when a tropical cyclone is threatening a coastal area.

Imagery enhancements, in both the form of greyscale manipulation and colour representation, are widely used to facilitate interpretation techniques.

WEFAX transmissions from GOES-W are received via a readout station in Brisbane and provide full coverage of southern hemisphere imagery for WMC Melbourne operation.

Occasional use is made of polar orbiting imagery from NOAA and METEOR satellites from local APT stations. Arrangements are made as necessary for APT reception in the Antarctic area to support summertime forecasting operations there.

(b) TOVS

All southern hemisphere SATEM data received over the GTS are used in the WMC analysis system.

TOVS data (in TIP form) are acquired directly by reception and processing of VHF Beacon Direct Broadcast. After sounding radiance preparation, discriminant analysis and multiple linear regression are used to produce temperature profiles for fifteen pressure levels, mixing ratio profiles for the first six standard levels, and geopotential thickness for the standard levels. The data can be processed to 70 km resolution within about 15 minutes of orbit time.

The routine display consists of analysed fields of 1000 - 500 Hpa thickness, 250 Hpa geopotential height (using interpolated MSLP analysis - prognosis values for orbit time as reference level), and superimposed geostrophic wind vectors.

(c) SATOB Data

Cloud vector winds from GMS, GOES and METEOSAT, received via the GTS, are routinely used in Melbourne WMC analyses. The GMS winds find particular application in the new automated tropical analysis scheme being run by Darwin RMC.

(d) DCP Data

Drifting buoy data are received over the GTS from Service Argos and provide vital surface pressure information for WMC analysis.

PART V PLANS FOR FUTURE OPERATIONAL SYSTEMS:

HRPT station are to be established in Melbourne and Perth in mid 1987 for research and operational purposes. The ARM system will include facilities for the ingestion of AVHRR data from Melbourne and later in Perth and in addition interactive processing of augmented TOVS data. AVHRR will also be processed by a stand alone workstation in Perth. Preparations are also being made to receive and utilise stretched VISSR imagery from GMS when it becomes available in 1988.

Small Data Utilisation Stations (SDUS) are planned for installation at the tropical cyclone warning centres in Brisbane, Perth in 1987 to provide quicker and more secure reception of GMS imagery at these critical locations. The Darwin SDUS was operational in 1986.

As regards TOVS processing, it is intended to move toward using a physical retrieval scheme operationally, in line with the sentiments expressed at the Third International TOVS Study Conference. A new one step scheme was recently implemented on the ARM system and testing was conducted during 1986.

The implementation of ARM into NMC occurred in 1986. In addition to the uses noted in part III it is hoped in the future this will give the ability to operationally generate cloud drift winds and TOVS retrievals in a manually interactive way.

In the period up to 1988, satellite based DCP will be installed at islands off the tropical coasts to provide back-up for AWS used for synoptic observations and cyclone warning purposes. Other DCP initiatives will include the establishment of an operational drifting buoy network in the Australian area from 1985 onwards and progressive installation of the new ASDAR units on QANTAS aircraft.

PART VI

Lead Scientists (Australian Bureau of Meteorology)

* Cloud Statistics Software	-	N. Davidson
* Cloud Systems related to three dimensional flow	-	I. Bell
* TOVS Retrieval and Australian Regional McIDAS	-	J. Le Marshall
* Operational Applications and Techniques	-	F. Whitby

Information on research projects and lead scientists at other Australian Institutions (Universities, CSIRO) may be obtained by contacting the Deputy Director (Research and Systems), Bureau of Meteorology, G.P.O. Box 1289K, Melbourne, Victoria, 3001, Australia.

BRUNEI

Brunei Meteorological Service

SUMMARY

There were no significant changes in the operation of the Medium Data Utilization Station (MDUS) at the Brunei Meteorological Service in 1986. Data was received during the year without serious interruptions. As in the previous years, the Japanese Geostationary Meteorological Satellite (GMS) has been the only source of satellite imagery in Brunei.

RESEARCH AND DEVELOPMENT IN THE APPLICATION OF SATELLITE DATA AND PRODUCTS

Forecasting is the main area where satellite imagery is being used. It has proved to be an invaluable tool in synoptic analysis. Being in the tropics, Brunei is continously faced with the problem of data sparsity. Providing forecasts for aviation and public services are therefore heavily dependent on satellite imagery.

Convective activity over the region and the movement of cloud clusters are studied in order to provide guidance in forecasting of heavy rainfall and flash floods.

The only derived products of GMS being used are the vector winds received via GTS, at both High-Level and Low-Level. The vector winds are used as a supplement to the synoptic data and are found very useful particularly over the tropical oceans.

TECHNIQUES DEVELOPMENT AND APPLICATION

At the present time the only means of extracting more information out of the satellite imagery received are the various curves and tables used for enchancement and estimation of Cloud Top Temperature.

Temperature Conversion tables for FAX-IR and albedo Coversion tables for FAX-VIS images are in use for estimating Cloud Top Heights.

Enchancing the imagery serves to bring into focus the deep convective cores of cloud clusters associated either with the monsoon or more localized tropical storms.

DESCRIPTION OF OERATIONAL SYSTEM IN 1986

The full disk high resolution and the eight-sector low resolution imagery from the GMS continued to be received. The high resolution imagery can be sectionized and enlarged for various user requirements. Sequences of 16 pictures can be stored and displayed in animation form with a choice of four psendo colour tables. Selected high resolution imagery can be recorded on tape and stored for later use. Low-resolution sectors are produced only in hard copy with the aid of laser fax. A time series of strips of full disk high resolution imagery covering 10°N-10°S has continued to be built up as well as a microfilm archive of daily pictures.

PLANS FOR FUTURE OPERATIONAL SYSTEMS

It is envisaged that with the upgrade of the present satellite receiving system to receive S-VISSR imagery from GMS by March 1988, more capabilities will be introduced into the system for manipulation and extraction of information from the received imagery. Plans are at present underway for this upgrade and the implementation phase will be reached by mid-1986.

VERIFICATION OF SATELLITE DATA AND PRODUCTS

Local area verification is done by comparison of satellite imagery and the weather radar. Wind vectors are monitored and checked against any available AIREP or radiosonde data. No other type of verification is done.

CANADA

This portion of the report summarizes the activities in satellite meteorology of a number of Atmospheric Environment Service components:

The Weather Services Directorate (WSD)
The Atmospheric Research Directorate (ARD)
The Central Services Directorate (CSD), and
The Canadian Climate Centre (CCC),
all located at 4905 Dufferin St.,
Downsview, Ontario
M3H 5T4

PART I - SUMMARY OF HIGHLIGHTS

Meteorological satellites continued to be an important data source for AES research and operations during 1987.

A new digital display system was developed for use with the satellite based communication system (METSIS). This communication system successfully passed its Phase I tests during 1986.

PART II - MAJOR RESEARCH AND DEVELOPMENT IN THE APPLICATIONS OF SATELLITE DATA

2.1 Satellite Sounding

TOVS soundings produced from direct readout data in Toronto were sent to the Maritimes Weather Centre in Halifax for real-time evaluation during the Canadian Atlantic Storms Program (CASP) field experiment from 15 January to 15 March 1986. The soundings were produced using a statistical algorithm with locally generated regression coefficients based on simulated measurements. The soundings were made available to forecasters staffing a special short-range forecast desk and case studies were examined by an operational forecaster after the field phase. The forecasters concluded that the soundings lacked sufficient detail, especially in the low levels, to be useful to a regional forecast office (MacAfee, 1986).

Tests of a simultaneous retrieval scheme using empirical orthogonal functions of temperature and relative humidity computed from radiosonde data as a basis for the retrieved perturbations were presented at the Third International TOVS Study Conference (Steenbergen, Greaves, and Yip, 1986). The results (for clear conditions only) were encouraging and work is proceeding on inclusion of the effects of cloud in a similar manner to that reported by Huang and Smith at the TOVS Study Conference. It is planned to make retrievals available for testing in numerical models during the coming year.

2.2 Quantitative Analysis of Satellite Imagery

The RAINSAT system continued to run quasi-operationally in the Toronto satellite receiving station (see previous report). Products were sent to the Maritimes Weather Centre during CASP as well as to the Quebec Weather Centre. Reports prepared by the operational staff indicated that the products were useful to them (Abraham, 1986). A statistical comparison of the probability-of-rain maps with weather radar data for the summer season indicated modest but significant skill in separating raining and non-raining clouds (King, 1986).

2.3 Microwave Remote Sensing

The Microwave Research Project is a program of research and development to ensure that the AES will be ready to make use of the microwave remote sensing data that will be available operationally at the end of the decade. The primary emphasis has been devoted to the use of Seasat Scatterometer wind data, Passive Microwave Radiometer liquid water, water vapour, and rain data for applications in regional short range forecasting. Studies indicate that these two data sets would significantly improve surface wind analysis and moisture analysis thereby resulting in improved wind and precipitation forecasting.

A response was prepared for the ERS-1 Announcement of Opportunities to utilize the Scatterometer data in near real-time in AES Weather Centres.

2.4 Ice Research

During 1986 the Ice Research and Development Division continued to develop algorithms to derive ice information (ice extent, ice edge, ice concentration and first year/old ice fraction), wind speed over open oceans, rain rate over oceans, and total atmospheric water vapour from passive microwave satellite data (NIMBUS-7 SMMR). A comprehensive plan to validate the Special Sensor Microwave Imagery (SSM/I) sensor to be launched on a DMSP satellite in 1987 was completed.

The Ice Research and Development Division was transferred to the Centre for Research in Experimental Space Science at York University. The objective is to create a world-class centre of expertise in the use of microwave data from satellites in the study of the atmosphere, oceans, ice and snow.

PART III - TECHNIQUES DEVELOPMENT AND APPLICATIONS OF SATELLITE DATA

3.1 Satellite Data Archives

The Satellite Data Laboratory operates a limited archiving program to support AES research programs. Thirty-day rotating digital archives are maintained for both the VISSR and A/VHRR data.

A system to archive GOES data is in place and operational. The routine archiving of GOES-E data will commence with the launch of the new satellite which is expected in February, 1987. Visible and infrared data are archived every three hours for the full disk at 8 km and 32 km resolutions. Limited areas over southern Canada will be archived in full resolution during daytime hours. AES is designated as the sector processing centre for GOES-E as part of the WMO ISCCP.

3.2 Hydrometeorology

The Hydrometeorology Division has carried out to a project to compare the ability of existing satellite techniques to derive daily, weekly and monthly precipitation estimates under Canadian conditions using GOES data. A modified life history method, the RAINSAT procedure and simple climatological techniques were evaluated by comparing the satellite-derived rain estimates with radar and gauge observations over a 440,000 square kilometre area in Eastern Canada. During 1986, this project was expanded to include the integration of remotely sensed and conventional information through objective analysis as well as the examination of some of the network implications of adding remotely sensed data.

As part of a study of the relationship between remotely sensed data and hydrological models, special snow cover analysis of a portion of the Saint John River Basin covering the melt periods in 1984 and 1985 was carried out in 1986. Multi-spectral data from the NOAA satellite were analyzed using the division's supervised digital classification scheme.

Research on the development of regional algorithms for determining snow depth and water equivalent using passive microwave data continues. Airborne and satellite (NIMBUS-7) passive microwave (37 and 18 GHz) data were collected over the Southern Canadian Prairies. Regressions of airborne microwave brightness temperatures vs. airborne gamma snow water equivalent data averaged over 25 km lines have been performed and tested on coincident satellite data with good success. Results indicated the need to consider snowpack structure and whether the snowpack is dry or wet. Water equivalent can only be determined for dry snow. The onset of melt, or even surface wetness, can readily be detected if the snowpack is being monitored regularly. A follow-on multi-agency airborne/satellite experiment will be conducted during the 1986/87 winter as part of the validation plan for SSM/I on the next US Defence Meteorological Satellite (DMSP). The major validation experiment is planned for 1987/88.

Monitoring of the satellite-derived surface water temperatures for the Great Lakes and Bay of Fundy continued as in previous years. Analyses of surface water temperatures on the Scotian Shelf and Grand Banks were done as weather conditions permitted. Temperatures are corrected for atmospheric attenuation using radiative transfer calculations based on radiosonde data.

3.3 Western Region

The Special Projects Office in Edmonton and the Yukon Weather Office are engaged in development activities and training in the application of satellite imagery to weather analysis and forecasting. The Special Projects Office development and applied research is directed towards Natural Hazards applications.

A methodology and computer program have been developed to diagnose hail size from HRPT data. Using cloud top temperatures from active thunderstorm updrafts which are extracted automatically a statistical technique has been developed to predict hail size reaching the ground. The technique was tested on an independent dataset this summer. Papers were presented at the AES/CMOS Workshop on Operational Meteorology and at the AMS Conference on Satellite Meteorology.

A project has been initiated to develop the capability to process TOVS data into synthetic soundings in Edmonton, using a statistical retrieval method. An operational system, fully automatic, is scheduled for completion in early 1987. It is planned to conduct experiments in using TOVS data for severe thunderstorm forecasting in Alberta in 1987.

Techniques have been developed to use NOAA BAND 3 imagery in detecting stratus, fog and other cloud forms. A paper was presented at the AES/CMOS Workshop on Operational Meteorology.

PART IV - SATELLITE APPLICATIONS IN OPERATIONAL USE IN 1986

4.1 The AES Satellite Read-out System

Data for operational use were received from geostationary satellites, GOES-6 and METEOSAT (Wefax), and from polar orbiting satellites of the NOAA and METEOR Series. The direct readout system consists of geostationary satellite VISSR readout stations in Vancouver and Toronto and polar orbiting satellite HRPT readout stations in Edmonton and Toronto. These stations are linked to weather forecast centres by dedicated communications lines carrying satellite imagery in photo facsimile format. Circuit schedules for transmission of satellite imagery are coordinated through a consensus of users on each circuit. The Vancouver VISSR readout station has a direct communications link to the Meteorological Data Analysis System (METDAS) in the co-located weather forecast centre. The METDAS is used for computer satellite image analysis, including image enhancement, film-looping of images on a CRT colour monitor and overlaying satellite imagery with other meteorological fields. In addition to these readout and distribution centres, the AES operates APT readout stations at Whitehorse, Inuvik, Resolute, Frobisher Bay and Yellowknife, a shared HRPT readout station in Greenland and a METEOSAT WEFAX readout station at Gander.

The GOES Readout Stations at Toronto and Vancouver have been equipped with 'MAGIC' boxes to convert the new mode AAA stretch VISSR data format to Mode A.

4.2 Pacific Weather Centre

The Pacific Weather Centre (PWC) has become an operational production centre for satellite products. Distribution to outside users is by a photofacsimile network terminated by Unifax printers. At the current time, the primary users are the regional weather offices.

PWC has developed a large number of satellite products that are of interest to other centres. Plans are in place to begin distributing the satellite products to other weather centres. The Pacific Weather Centre has a high speed digital data link with the Canadian Meteorological Centre (CMC). Over this line, CMC sends grid point data of the most recent analyses and prognoses to PWC. The same line will be used to send back satellite products.

At the same time PWC has been developing enhancements to its operational display station. It will now receive data transmitted through commercial grade telephone lines. Simultaneously, the software has been implemented within the satellite facility for the transmission of digital satellite data over as many as eight data lines (to local and remotely located display stations).

The PWC now has the benefit of a NESDIS GOES-Tap satellite data service. This has increased the data base since it allows for the reception of the Geostationary Meteorological Satellite (GMS) imagery. The PWC operational forecasters can now analyze atmospheric dynamics as far upstream as Eastern Asia. Work is underway to integrate the GMS imagery into the PWC satellite facility and distribute the data over the AES photofacsimile networks.

Work has commenced on the software for remapping image data to the polar stereographic projection and for normalization of the visual data. This capability will allow the further development of the Pacific Region precipitation algorithm.

The satellite facility has been intensively used for the operational study of rapid cyclogenesis over the Pacific, i.e., storms that are increasingly referred to as "bombs". It is hoped that this will provide the information necessary for the improved forecasting of developing storms.

4.3 Canadian Ice Centre

The Ice Centre continues to receive and utilize NOAA AVHRR hard-copy imagery for daily ice analysis and forecasting. Data were received on UNIFAX-II photo-recorders from the AES HRPT receiving stations at Toronto and Edmonton, and from Söndre Strömfjord, Greenland. LANDSAT-4 data were also received in a similar fashion from the CCRS facility at Prince Albert, Saskatchewan. Additionally, digital NOAA AVHRR data on CCT was shipped by courier from Edmonton weekly and processed on the DIPIX Aries-II for integration into the composite ice charts.

Research into digital image enhancement techniques for NOAA AVHRR data as well as airborne and satellite radar data continued on the Aries-II image processor. This work concentrated on automated image navigation techniques and in determining acceptable image resolution required for operational ice analysis. To facilitate this work, a high speed communication link was installed between the Satellite Data Laboratory and the Ice Centre to receive digital AVHRR imagery in near real-time.

PART V - PLANS FOR FUTURE OPERATIONAL SYSTEMS

5.1 Satellite Readout Facilities

The existing processing systems at Toronto and Edmonton are being replaced with state-of-the-art processing facilities. These facilities will be fully automatic, and allow direct digital and analog output on a number of ports. These facilities will be connected to the new satellite-based distribution system developed by AES's Computer and Communications Services Branch. This will allow direct broadcast of the data to users. Delivery of the two readout systems is expected in the autumn of 1987.

5.2 Communication of Satellite Data

Equipment and software to receive data from the GOES Data Collection System (DCS) has been installed in Downsview and Vancouver. Both became operational in 1986.

AES has 59 DCP assignments, including four in the ASAP program, in addition it has sensors on water survey platforms.

Most AES DCP's report hourly; however, 12 are 3 hourly, and the ASAP systems are 12 hourly. There are no random reporting sites. At present 53 DCP's are active, and 5 are expected to be activated during Spring/Summer of 1987.

A Meteorological Satellite Information System (METSIS) trial system was installed, consisting of one uplink at Downsview, and 9 receiver sites across the country as Phase I. This system received bulk data from the Canadian Meteorological Centre (CMC) and the Satellite Data Lab (SDL), and weather charts from Ontario Region and distributed it using 56 Kbps channels to receive only earth stations.

In the operational trial, photos and charts were displayed on existing mechanical recorders which were retrofitted to accept digital input. These devices will be replaced in Phase II by Multi Purpose Display Stations (MPDS). The MPDS is a microcomputer based unit capable of displaying charts, photos, overlays, zoom, etc., and will have a hard copy device associated. Prototypes were delivered, tested and evaluated in 1986.

In 1987/88 and 1988/89 (Phase II), another 60 receive-only sites will be installed as well as an uplink at CMC in Dorval. In early 1988/89, the Edmonton station will be upgraded to an uplink for transmitting HRPT data to Ice Central in Ottawa as well as transmitting satellite image data to Vancouver and Downsview.

PART VI - VALIDATION AND VERIFICATION OF SATELLITE DATA AND DERIVED PRODUCTS USED IN OPERATIONS, INCLUDING PERFORMANCE STATISTICS

Nil

PART VII

7.1 Contacts

SATELLITE SOUNDING QUALITATIVE ANALYSIS OF SATELLITE IMAGERY

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SOLAR RADIATION APPLICATIONS

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WESTERN REGION

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7.2 References

Steenbergen, J.D., B.T. Greaves, and T.C. Yip, 1986: Simultaneous Retrieval of Temperature and Relative Humidity Using Empirical Orthogonal Functions. Technical Proceedings, Third International TOVS Study Conference, Madison, Wisconsin, 13-19 August 1986. Co-operative Institute for Meteorological Satellite Studies, 1225 West Dayton Street, Madison, Wisconsin, 53706, U.S.A.

Abraham, J.D., 1986: Evaluation of RAINSAT products during the Canadian Atlantic Storms Program (CASP). Atmospheric Environment Service, Atlantic Region Technical Note No. 86-003(N).

King, P., 1986: Results from a Real-time Test of RAINSAT. Proceedings, First Workshop on Operational Meteorology, Winnipeg, Manitoba, 4-6 February 1986, pp. 84-88. Atmospheric Environment Service/Canadian Meteorological and Oceanographic Society.

MacAtee, A., 1986: TOVS - An Operational Evaluation During CASP. Atmospheric Environment Service, Atlantic Region Technical Note No. 86-007(N).

Determination of Snow water equivalent on the Canadian Prairies using microwave radiometry. Goodison, B.E., I. Rubinstein, F.W. Thirkettle, E.J. Langham, 1986. In: Modelling Snowmelt-Induced Processes, IAHS Publ. No. 155, IAHS Press, Wallingford, U.K. p. 163-174.

This portion of the report summarizes the application of satellite technology to operational hydrology.

Environment Canada is nearing the end of a 5 year program to establish a network of 350 water resources monitoring stations at remote sites across Canada which will transmit water quantity data via satellite.

These data collection platforms (DCPs) as they are known, automatically collect data on water conditions, as well as station performance characteristics, and broadcast these data at regular intervals to a satellite in geostationary orbit. The satellite relays the data through ground stations to Environment Canada regional offices for final distribution to users. The platforms which provide the satellite transmission capability were designed and manufactured by Bristol Aerospace Limited of Winnipeg.

One third of this $2 million dollar project is being expended to provide this capability at water resources stations located in the Yukon and Northwest Territories. 18 of these DCPs were installed also in the Atlantic Region, mainly in the Province of Newfoundland and Labrador.

A number of the new sites are remote and will enable Environment Canada to verify the operating status of the stations without incurring expensive fly-in trips. The DCP network is still in the preliminary mode, and any costs savings have not manifested themselves as yet.

Since the data collected represents a recent hydrological event (a few hours before receipt of the data) it can be used in "real-time" operation. For example, stations on the Mackenzie River and its tributaries in the Northwest Territories provide data on water levels to be used by barge operators for river navigation. Other data uses include flood forecasting to assist emergency measures activities and flow forecasting for reservoir operation.

In addition to water resource data, some stations provide information on ice conditions including ice formation, break-up and jamming; a knowledge of which is a requirement for travel in the north. Data on station performance allows Environment Canada staff to optimize trip scheduling. This has already resulted in operational savings since trips in the arctic normally cover large distances and are made using costly fixed wing aircraft or helicopters.

Photovoltaic cell and storage battery systems harness solar energy to power the satellite telemetry instrumentation. Environment Canada has pioneered the use of these small independent power systems in an arctic climate because of their attractive operational characteristics. They pose no ecological threat to the local environment and they are relatively maintenance free. To further improve efficiency and increase the power systems output capability, Environment Canada is currently participating in a $100,000 research and development project with the Department of Energy, Mines and Resources.

The need to monitor and assess a broad spectrum of ecological changes instigated by man or by natural events is particularly important in the fragile Arctic environment. This requirement was foreseen and each satellite telemetry system has been designed to accommodate sensors which provide data on local environmental conditions such as weather, water quality, snow accumulation etc. With these data available from a network that spans the Canadian North, scientists will have the necessary information to make more accurate impact assessments.

Not all sites selected for DCPs are remote. Some were chosen with real time data reporting in mind. For example, the Atlantic Region produces an extensive monthly surface runoff report with data form 15 synoptic stations used. Eight of these stations are now equipped with DCPs and the daily data transmissions provide useful information for the compilation of the monthly runoff report.

As has been the case for the past 15 years, DCPs in the Saint John River Basin in the Province of New Brunswick have been used to provide up-to-date flow data during freshet and other high flow periods for input into the SSARR and DWOPER models of the Saint John River Forecast Centre. Data generated from the SSARR model are then utilized for input into the SOCH model used by the New Brunswick Power Corporation to help it in operating the hydroelectric dams at Grand Falls, Beachwood and Mactaquac.

Under contract to Environment Canada, the consulting firm of A.J. Robinson & Associates Incorporated of Kanata, Ontario, demonstrated the use of snow cover and land cover information, developed from NOAA and Landsat satellite data, respectively, as input to the conceptual, hydrological simulation model SSARR. In addition, snow water equivalent information was obtained from airborne gamma ray surveys and used in the SSARR modelling application. The development of the remotely-sensed inputs and their use with the SSARR mdoel was fully documented. The use of streamflow data communicated in real-time via electronic data collection platforms (DCP) with the SSARR model in an operational forecasting mode was also discussed in the report.

The project was essentially a demonstration of three state-of-the-art remote sensing techniques, as they were used in an application of the SSARR model to the Tobique Sub-basin of the Saint John River Basin in the Province of New Brusnwick. The three remote sensing techniques are: (1) estimating of snow-water equivalent using the airborne gamma radiation technique; (2) delineation of snow-cover extent using NOAA digital data; and (3) land-use land-cover classification based on Landsat TM imagery.

(1) Snow Water Equivalent

The gamma radiation data collected during the springs of 1984 and 1985 were analyzed to develop areal estimates of snow water equivalent. Two analysis techniques were employed: the trend analysis method which has been used by the Saint John River Forecast Centre (SJRFC) with conventional snow course data; and a recent technique called the correlation-area method (CAM) which integrates several different kinds of data (e.g. point, line, areal).

Results of the two methods of analysis were quite comparable. An interesting trend observed in both analyses is the decrease in snow water equivalent as elevation increases. Each of the methods has its advantages; for example, the trend analysis method accounts more realistically for elevation, whereas the CAM is much easier and cheaper to sue. These techniques were fully evaluated in the report.

The results of the analyses were used to update the snow water equivalent parameter in the SSARR's snow melt routine.

(2) Snow Cover Analysis

Environment Canada's Atmospheric Environment Service carried out an analysis of full-resolution (about 1 km) NOAA digital data to provide estimates of snow cover extent over the watershed, by elevation bands, for selected days in 1984 and 1985. Some definite trends were observed - in particular, the increase in snow cover extent with elevation. A comparison of this NOAA digital technique was made with an image analysis technique which has been used to provide the SJRFC with snow cover mapping in past years.

The snow cover data were used in conjunction with the development and updating of the snow cover depletion curve in the SSARR model.

(3) Land Cover Analysis

Landsat Thematic Mapper (TM) imagery of July, 1985, were analyzed to obtain a better estimate of the canopy cover over the watershed during the spring runoff period. The SSARR's general melt equation contains a canopy-cover parameter.

Two TM false colour composited images were ordered from the Canada Centre for Remote sensing. The three TM bands were selected specifically to enhance the spectral differences of coniferous and deciduous forests. The images were video-digitized, the digital data were stored on floppy diskettes, and a classification analysis weas carried out using image analysis software on an IBM-PC-AT micro-computer. Using 1:20,000-scale New Brunswick forests resource inventory maps as "ground-truth", coniferous and deciduous forest types were classified with an error of only 5%.

The canopy cover over the watershed during the spring runoff was assumed to be restricted to those areas of the watershed covered by coniferous forest.

PEOPLE'S REPUBLIC OF CHINA

Satellite Meteorological Center
State Meteorological Administration
Beijing

The main progress in the field of satellite meteorology in the Satellite Meteorological Center, the State Meteorological Administration, the People's Republic of China are as follows.

1. The TIROS-N/GMS system under the funding of UNDP, WMO and PRC has been completed. Some products have been put into routine operation, and some in experimental operation.

Among the products in routine operation, there are M-70 image processing system and software package of three orbits mosaic. The products in experimental operation are the distribution of atmospheric temperature and humidity retrieved by TOVS data and the distribution of sea surface temperature retrieved by AVHRR data. From the results of the experimental operation, the retrieved accuracy of the atmospheric temperature is approximately 3° C in the lower troposphere, and 2 - 3° C in the upper troposphere. The accuracy of sea surface temperature is about 1.2° C.

In addition, the applications software of the calculation of outgoing longwave radiation using AVHRR data, the interpretation of sea ice, the software on determination of snow cover on plateaus, and the vegetation index have been developed in the Satellite Meteorological Center.

2. Various image products and processed products from the TIROS-N/GMS receiving and processing system and GMS equipment have been widely applied in the fields of weather monitoring, analyzing and forecasting as well as environmental monitoring.

- In the summer half year, the position and intensity of typhoon derived from satellite data are transmitted to local stations via telex lines.
- Beginning from 1, Oct. 1986, the colour display of mosaics of three orbits have been provided for broadcasting on TV every day, and sometimes the time-lapse pictures are provided also.
- Progress has been made in the monitoring of crops growing through the variation of vegetation index. The effects in the yields estimation of winter wheat and grass-producing amount are especially remarkable.
- In 1986, a forest fire in northeast China was successfully monitored with Channel 3 image or the composition of Channel 1, 2 and 3 of AVHRR, which achieved fairly good service results.
- In the flood season of 1986, flood and waterlogging occurred in Liao River and Songhua River respectively in northeast China. The situation of flood and waterlogging as well as the flood-stricken area were monitored using the Channel 2 image data of AVHRR and the calculated digital data of vegetation index, which served as a basis for the work of flood prevention and disaster relieving.

3. A new processing system scheme has been made and the design of equipment is under way in order to receive the stretched digital data broadcast by GMS in 1987.

COLOMBIA

Instituto Colombiano De Hidrologia,
Meteorologia Y Adecuacion De Tierras - HIMAT

PART I

SUMMARY OF MAJOR HIGHLIGHTS

Using the equipment installed in Bogota, low-resolution images of cloud cover can be obtained in black and white in the visible and infra-red spectra.

PART II - DEVELOPMENT IN THE APPLICATION OF SATELLITE DATA, DERIVED PRODUCTS AND SERVICES

Not applicable

PART III - TECHNIQUES FOR THE APPLICATION OF SATELLITE DATA, DERIVED PRODUCTS AND SERVICES

The images are used in synoptic analysis, short-range forecasting, tracking the trajectory and development of cyclones, study of cloud systems associated with the inter-tropical convergence zone and as background in information in air navigation.

In hydrology the information is used to forecast river levels.

PART IV DESCRIPTION OF THE SYSTEM IN OPERATIONAL USE IN 1986

CIT-ALCATEL APT/WEFAX receiving station.

PART V OTHER ITEMS

Not applicable.

CZECHOSLOVAKIA

I Major highlights of research applications and operational changes

Received satellite AVHRR and METEOSAT data after primary processing at two stations on Prague and Bratislava are distributed to hydrometeorological centers for prognostic purposes. Some of them are transformed into a unified cartographic system and further propagated by means of an OLT22 facsimile transmitter. The research has continued in the area of utilization of satellite data for numerical weather prediction, hydrology, agrometeorology, climatology, etc.

II Major research and development in the applications of satellite data, derived products and services

The data are distributed to a wide range of potential users situated mainly in prognostic centers and airports as described under point I of this report. Further they are used, e.g., for

- studying summer storms, where relations between the intensity or the character of the storm and the character of the radiation field at the upper boundary of the Cb clouddiness are examined;
- development of algorithms for the computer classification of cloudiness based on combined spectral and textural features of the imagery. These results can be used, e.g., in the initialization of numerical prognostic models;
- determination of the probable development of cloudiness within next tens of minutes.

The research is supported by own programmes, written mainly in FORTRAN, and making it possible to apply a wide range of digital image processing techniques to the satellite imagery. These programmes are available to potential users.

III Techniques development and applications of satellite data, derived products and services

Received data after thermal calibration are geometrically corrected (AVHRR), radiometrically enhanced, visualized, possibly enlarged and finally dispaatched by means of communication lines to hydrological and meteorological prognostic centers in Prague and Bratislava and to the airports in these two towns.
The thermal IR data are temperature-contoured for distinguishing the top level of clouds.
Image animation from METEOSAT is dispatched to Prague and Bratislava airports in the form of colour TV images. The videorecorder enables to get the actual picture information at any time.

IV The system for satellite applications in operational use in 1986

The configuration is much the same as described in the 1985 report. It consists of:

1. Prague:
   AVHRR receiving and processing MACDONALD DETTWILER ASSOCIATES LTD. system installed in 1979 and including:
   4.5m autotrack parabolic antenna, low noise GASFET preamplifier, communication receiver, bit synchronizer, AVHRR frame formatter, WIP weather image processor MDA 882, tape drive 1600/800bpi, Muirhead hard copy registrator K560, operator console.

2. Bratislava:
   AVHRR and METEOSAT receiving and processing system WIRPS-Dornier installed in 1983 and including:
   3m parabolic programmable antenna, antenna preamplifier, communication receiver, bit synchronizer, formatters, PDP 11/34 computer, disk drive, tape drive 1600/800bpi, COMTAL colour display, Muirhead hard copy registrator.

V Plans for future operational systems

High rate data radio relay link is presently under construction in Prague.It should deliver satellite data to the meteorological computer center in Prague from the MDA apparatus in real time.

VII References, publications, name, and addresses

Results of the research are usually published in the Czech meteorological journal "Meteorologicke zpravy". Results of the combined textural and spectral analysis of the meteorological imagery were presented at the COSPAR Plenary Meeting XXVI, Toulose 1986.
The addresses of institutes and names of leading scientists are:

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RNDr. Dusan Podhorsky, CSc.
Slovak Hydrometeorological Institute
Maly Javornik
835 15 Bratislava

ETHIOPIA

National Meteorological Services Agency

PART I

The main event of 1986 in the application of satellite technology has been the installation of a PDUS/SDUS system at the National Meteorological Centre in Addis Ababa. The National Meteorological Service Agency has been operating an APT/PDUS/SDUS Meteorological Satellite receiving system since July 1986.

PART II

Nil

PART III

Sectorized geographical area high resolution hourly images from METEOSAT 2 are received on the PDUS system in the visible, infrared and water vapour channels. These images are displayed on RGB Video Monitor. Temperatures can be measured within an accuracy of 1°C in the infrared channel. Cloud top temperatures in arbitrary assigned colours are made to identify deep convective or stratified clouds which can produce rain. Both zoom and time-lapse loops up to 8 images can be displayed on the RGB Monitor to study in detail cloud systems and their movements. On the SDUS system full disc and sectorized WEFAX images are received and displayed on a black and white video monitor. These WEFAX images are used to identify global and synoptic meteorological systems to aid the routine meteorological analysis and forecast. Photo quality hard copy of images both from PDUS and SDUS systems can be recorded on the laserfax. Automatic picture transmission from NOAA satellites are received as a back-up to survey the Indian Ocean area which is not covered by METEOSAT.

PART IV

The National Meteorological Services Agency is utilizing meteorological satellite images to supplement conventional data in preparation of weather forecast for various economic activities of the nation. The satellite images are used in weather forecast presentation in the Ethiopian Television Service and this has made the presentation more interesting and much easier for the public to understand. The farming community and the early warning system has benefitted in the medium-range forecast provided by the Agency utilizing the satellite information. The operation of the area survey in some parts of Ethiopia have utilized the visible satellite pictures specially for mapping the south-west part of the country.

PART V

The Agency has a plan to acquire an HRPT receiving systems and to utilize DCPS for data collection via METEOSAT.

PART VI

No systematic work has been done in this area.

PART VII

Nil

EUMETSAT

Introduction

EUMETSAT is a new inter-governmental organisation created in 1986 to establish, maintain and exploit European systems of operational meteorological satellites.

EUMETSAT is governed by a Council with delegates from 16 member States (see below). The day to day activities of EUMETSAT are conducted by a small secretariat. The Headquarters of EUMETSAT is located in Darmstadt within the Federal Republic of Germany.

The primary motivation for the creation of EUMETSAT was the success of Meteosat, the European meteorological satellite developed by the European Space Agency (ESA). Meteosat-1 was launched in November 1977 and operated on behalf of the meteorological community by the European Space Operations Centre (ESOC), an ESA establishment also located in Darmstadt. The follow-on satellite, Meteosat-2, is still providing routine images more than five years after its launch.

The initial task of EUMETSAT is to ensure the continuation of the Meteosat satellite system by funding and administering the Meteosat Operational Programme. The operation of the new MOP satellites and of Meteosat-2 and Meteosat-P2 is also under the overall responsibility of EUMETSAT. ESA will continue to execute the Meteosat Operational Programme on behalf of EUMETSAT. This means that ESA will supervise the actual building and launch of the satellites and ESOC will conduct day-by-day operations as before. EUMETSAT, however, will provide all of the funding, make policy decisions and undertake user liaison.

The Meteosat Operational Programme is funded until the end of 1995 and is the only major EUMETSAT activity so far approved by its Council. However, the secretariat are now involved in ESA's plans for a second generation Meteosat, due for operation in the years from 1995. EUMETSAT will define the operational requirements for this new series although it is expected that ESA will actually develop the satellite. EUMETSAT is also involved, with ESA, NASA and other international agencies, in preliminary studies concerning the Polar Platform, also due for launch in the mid 1990's. EUMETSAT is also studying a number of ground based systems which could, if implemented, improve the utilisation within Europe of existing satellites, including both Meteosat and the current series of USA polar satellites.

PART I A brief summary of the major highlights of research applications and operational changes.

Overview

Since the end of 1983, the exploitation of the Meteosat-2 satellite system has been part of the Meteosat Operational Programme (MOP).

The construction of the three operational satellites, to be launched in 1988, 1989 and 1990, has continued according to plan in European Industry under the prime contractorship of Aérospatiale (France). The launches will be performed by the European launcher Ariane.

In order to fill the gap until the launch of the first Meteosat operational satellite, MOP-1, in late Spring 1988, a refurbished prototype, P2, of the preoperational satellite series and similar to Meteosat-2 will be launched towards the end of 1987.

Meteorological Operations

The production of meteorological parameters continued according to plan throughout 1986 with negligible interruption to services. An important change to routine meteorological operations occurred during the year in the form of the production of cloud motion vectors for 0600UT, on an experimental basis, with effect from the middle of May 1986. After a trial period of six months it has been decided that the production of 0600UT winds should continue.

A consequence of this change has been the cessation of production of the 0800UT cloud top height product.

The production of the MIEC Precipitation Index (PI), although still an experimental product, is now fully automatic. Routine archiving of the data started on 18 September 1985. Some studies have started on the validation of this product using ground truth rainfall data from five African countries.

Investigations were conducted during the year to reduce the negative speed bias of high level cloud track winds using a windowed radiance technique. Initial results have been very encouraging. In addition a new atmospheric correction scheme has been tested which calculates the atmospheric corrections to radiance values individually for every processed image segment based upon the forecast atmospheric profile for the segment as derived from ECMWF forecasts.

Ground Segment Refurbishment

The refurbishment of the ground segment continued during the year and is nearing completion. The main components involved have been the back and front end computers, the supply and integration of equipment for data acquisition, the telecommand and tracking equipment, Meteosat compatible telecommand equipment, ranging system, and receivers for the Data Collection System.

Part II A description of the major research and development in the applications of satellite data, derived products and services.

Precipitation Index (PI)

There is a growing interest in such an index for a wide variety of climatological purposes, studies on general circulation, agrometeorological applications and forecast model verifications. In the World Climate Research Project the lack of reliable estimates of tropical precipitation is considered to be one of the most serious bottle-necks for progress.

The Meteosat PI has been formulated bearing in mind that

- the index should be comparable to the one used at NOAA, to obtain a globally meaningful product.
- the index could be produced with little human intervention
- the processing should be similar to that used in the determination of other meteorological products.

Consequently, the formulation by Arkin (1979) was considered the most appropriate. In addition, it has been agreed that this type of index will be used for the Global Large-Scale Precipitation Data Sets for the World Climate Research Programme.

The index introduced at ESOC is, however, slightly different from the one used at NOAA. First, the spatial resolution is about 1.5 x 1.5 deg., instead of the 2.5 x 2.5 deg. data derived by NOAA. Secondly, the upper tropospheric humidity product derived from the WV channel is also stored, since it may be a useful parameter in the determination of actual precipitation (Adler and Mack (1984)).

The precipitation index is archived on magnetic tape and four or five tapes are required for one year of data.

PART III A description of techniques development and applications of satellite data, derived products and services.

Technical developments for P2

Preparations for the launch of P2 on the first Ariane-4 flight, delayed until late autumn 1987 are nearing completion. All tests on the spacecraft have been successfully completed and the satellite is now in store awaiting launch.

Technical improvements for Operational METEOSAT

The MOP satellites are an improved version of the pre-operational Meteosat series, to which P2 also belongs. There will now be the possibility for simultaneous transmission of visible, infrared and water vapour channel data and each channel will be coded in eight bits instead of six. In addition, a two-channel 2400 b/s repeater function will be added to the main satellite transponder, designed for Meteorological Data Distribution (MDD) to Africa and the Middle East.

ISCCP Activities

As a participant in the World Climate Research Programme ESOC continued to perform the functions of a sector processing centre within the overall data flow scheme of the International Satellite Cloud Climatology Project (ISCCP). The archived ISCCP data sets consist of Meteosat image data sampled at the following resolutions:

- B1 data set 10km resolution
- B2 data set 30km resolution

The data are sampled at 3 hourly intervals (main synoptic hours) and visible image pixels are averaged to match infra-red pixel resolution. Either four days of B1 data or one month of B2 data can be stored on one 6250bpi magnetic tape. B1 data is retained for five months and B2 data indefinitely.

PART IV A brief description of the satellite system in operational use in 1986.

The Meteosat-2 satellite system currently operated by ESA, on behalf of EUMETSAT, is fully described in WMO Publication No. 411.

The U.S. GOES-4 satellite, located over the equator at 43 deg. West, will continue to support the data collection mission until Meteosat P2 becomes operational towards the end of 1987.

Meteosat-2, now in orbit for more than 5 years, continues to support imaging and dissemination missions. The total Meteosat system has continued to provide services to the meteorological community with a high degree of reliability, i.e. more than the specified 95 % availability.

PART V Plans for future operational systems of satellites with applications for meteorology and operational hydrology.

2nd Generation Meteosat

The definition of Meteosat Second Generation (MSG) which will follow on from the Meteosat Operational Programme in 1995 is continuing. The prime missions are supported by:

- an 8 channels visible-IR imaging radiometer
- an infrared/microwave sounder
- a comprehensive data circulation package providing for data dissemination, DCPs and GTS support

Compared with MOP satellites, the new generation will provide:

- images with increased spectral resolution
- images with better spatial resolution
- atmospheric soundings with high time resolution
- dissemination of raw data to users
- more rapid data dissemination
- a more efficient scheme of data users stations.

Missions and system studies are continuing and a baseline definition of the mission specifications is expected later in 1987.

PART VI Validation and verification of satellite data and derived products used in operations, including performance statistics.

Overall performance

Performance figures for the three basic missions in 1986 were:

1986	Image Acquisition	Image Dissemination	Data Collection
January	99.2	98.3	98.5
February	96.4	95.8	94.2
March	98.9	99.1	98.8
April	99.1	97.8	99.6
May	96.5	95.7	99.6
June	97.2	98.0	98.8
July	98.4	98.2	98.3
August	94.2	94.0	95.5
September	99.2	99.2	98.7
October	98.7	98.3	97.6
November	96.7	97.1	97.0
December	98.5	98.9	99.3

Percentages indicate the performance achieved in relation to a ground segment with 100 % availability.

Data Collection Mission Performance

The status at 31 December 1986 was :

DCPs admitted :	279
DCPs reporting during December 1986:	71
DCP messages received during December 1986:	20213
System availability during December 1986:	99.3 %

(some data were lost because of ground station refurbishment)

Meteorological Information Extraction Performance

The production and dissemination of products in 1986 was:

1986	Cloud Motion Vectors (CMV)	Sea Surface Temp. (SST)	Upper Tropos-pheric Humidity (UTH)	Cloud Analysis (CA)	Cloud Top Height (CTH)
January	100	100	100	100	95.2
February	98.2	96.4	98.2	98.8	94.6
March	100	100	100	100	99.2
April	100	100	100	100	98.3
May	97.5	96.8	98.4	98.9	96.3
June	97.8	98.3	98.3	98.9	96.7
July	98.9	100	100	100	97.9
August	93.6	98.4	98.4	96.8	93.6
September	98.9	100	100	100	98.9
October	98.9	100	100	100	97.9
November	97.8	96.7	98.3	98.9	96.7
December	100	100	100	100	98.9

(Figures indicate the percentage of products distributed against a theoretically perfect system). For the time being the production of 0600UT cloud motion vectors prevents the production of 0800UT CTH information.

Meteosat Data Service and Archive Performance - 1986

	RETRIEVAL					ARCHIVE						
	Photographic		Digital			Photographic				Digital		
						20*20cm		F.Disk	Other			
	Orders	Products	Orders	Tapes	Sc*Chann	I.R.	VIS	W.V.	All	I.R.	VIS	W.V.
January	7	167	4	40	1261	93	63	93	89	1485	1021	1113
February	28	373	6	23	3381	97	65	107	88	1307	892	989
March	22	429	4	14	1145	96	64	101	94	1380	1021	1008
Total 1st Quarter	57	969	14	77	5787	286	192	301	271	4172	2934	3110
April	16	123	9	52	485	97	64	98	99	1406	985	1049
May	12	189	1	9	1099	99	66	123	88	1449	984	1099
June	3	12	4	65	1858	95	68	95	65	1160	794	873
Total 2nd Quarter	31	324	14	126	3442	291	198	316	252	4015	2763	3021
July	29	516	5	77	3377	94	62	103	96	1482	1021	1108
August	17	355	5	123	4338	106	86	105	110	1406	959	1059
September	19	319	4	76	14290	92	62	93	100	1324	983	968
Total 3rd Quarter	65	1190	14	276	22005	292	210	301	306	4212	2963	3135
October	15	195	6	98	1565	103	77	103	118	1435	1012	1070
November	25	303	5	13	1692	90	66	93	106	1408	969	1060
December	23	265	8	127	4804	95	65	97	96	1481	1017	1111
Total 4th Quarter	63	763	19	238	8061	288	208	293	320	4324	2998	3241
Total Year 1986	216	3246	61	717	39295	1157	808	1211	1149	16723	11658	12507

PART VII Other items (references, publications and the names of scientists in charge, etc.)

Addresses

Overall responsibility for the programme:

The Director
EUMETSAT
Am Elfengrund 45
6100 Darmstadt-Eberstadt
Federal Republic of Germany

Authority responsible for the execution of the Meteosat Operational Programme:

Head of Meteosat Operational Programme
The European Space Agency
8-10, rue Mario Nikis
75738 Paris Cedex 15
France

Authority in charge of routine operations:

Head of Meteosat Exploitation Programme
European Space Operations Centre
Robert Bosch Strasse 5
6100 Darmstadt
Federal Republic of Germany

FRANCE

Centre de Météorologie Spatiale (CMS)
Lannion

Part I - Summary of Major Highlights

I.1 Supply, on a operational basis, twice per day, of the data from the TOVS sonde associated with the characteristic parameters of the cloud cover in the HIRS-2 spot beam obtained from the AVHRR channel 4. These data are used in the analysis of the fine-mesh forecasting model.

I.2 Standardization of the calibration of the GMS and METEOSAT satellites with respect to the NOAA polar-orbiting satellite and the WMO/ICSU ISCCP project.

I.3 Since the third TOVS conference (ITSC-III), the CMS research team will be acting as a contact point during 1987 in co-operation with NOAA/NESDIS for navigational and calibration problems concerning NOAA satellites.

Part II - Major Research and Developments

This year studies have continued, relating to:

II.1 Satellite pre-processing, calibration and navigation

II.1.1 Reports on this subject were submitted to the international conferences ITSC-III and AVHRR-I. The centre will act as a focal point for questions concerning the sensors of NOAA satellites until the next conference

II.1.2 A procedure is being established for the systematic comparison of satellite radiances from the HIRS-2 and AVHRR sensors with synthetic radiances obtained from models for calculating the transmission in the neighbourhood of a few radiosounding locations.

Contact: G. Rochard

II.1.3 Preparation of a note on geographical positioning of AVHRR images from NOAA satellites (also available in English).

Contact: P. Brunel

II.1.4 As regards ISCCP, the results of standardizing the calibration of METEOSAT, GMS and GOES-5 satellites with respect to the AVHRR sensor of NOAA satellites have been prepared at 3-monthly intervals for the period July 1983 to July 1986.

Contact: G. Therry

II.2 The algorithms for the combined use of data from the HIRS-2 sonde and the AVHRR display of the NOAA satellites.

Contact: H. Le Gleau

II.3 Developing and validating a method for calculating the short-wave flux at the surface using data from the METEOSAT visible channel.

Contact: P. Le Borgne

Part IV - System in Operational Use in 1986

There has been no significant change with respect to the system described in 1984 and 1985.

IV.1 NOAA polar-orbiting satellites

The functions of acquisition, processing and transmission which hitherto were covered by specific computers will in future be covered by a single computer.

The following operations are undertaken on a routine basis:

- Systematic reception of high-resolution data when the satellites are in view at Lannion;

- A sliding one-year archive of all data received, and a data distribution service.

Contact SATMOS: P. Brunel

- Distribution of part of the imagery to the central forecast centre in Paris;

- Study of the thermal structure of the sea surface (Mediterranean and Eastern Atlantic) from combinations of AVHRR channels (Publication of a monthly bulletin, SATMER, available by subscription)

- Combinations of TOVS/AVHRR data were provided for the analysis of the fine-mesh forecasting model, for a night-time orbit only, until 1986; thereafter they are to be provided regularly twice per day.

- Relays of STIP data for NOAA via GOES-East.

IV.2 Geostationary satellites

IV.2.1 METEOSAT

- High-resolution acquisition of the Europe format (every half hour) and of the full-disk format (6 times per day);

- Transmission to all the forecasting and information stations (via the METEOTEL system) of imagery in polar stereographic projection (every half hour) and of a nephanalysis (4 times per day).

IV.2.2 GOES

Acquisition of high-resolution data and re-transmission of part of the imagery, after re-formating, to METEOSAT.

Part V - Plans for Future Operational Systems

Renovation of the computer centre will be undertaken during the second half of 1987. This opportunity will be taken to re-write all acquisition and processing programmes.

Centre National de Recherches Météorologique (CNRM)
Toulouse

1. Mapping frost-prone areas

The study of the data from the "Spring Frosts 1985" campaign has been completed. An analysis has been made of the maps of representative areas of surface observing stations derived from METEOSAT and AVHRR infrared imagery using appropriate procedures. The results show, in particular, that the method used enables maps to be obtained of the areas of which a station is representative. Both the AVHRR and METEOSAT maps show homogeneous zonings largely related to the station, of variable dimensions and location, depending on the station and the meteorological situation. By taking the part common to zonings corresponding to a given station, for all the days under study, a restricted zone, which is much more significant, is obtained. However, the AVHRR results are dlstinguished from the METEOSAT maps in that they show zones which are more diffuse, thus bringing out the influence of relief.

A working note by the EERM, No. 153 "Use of AVHRR data for the study of frost-prone areas on EMIR" (R.M. Thepenier, F. Cayla, April 1986) deals with this study.

2. Operational use of surface albedos

This year, algorithms have been developed, enabling surface albedos to be obtained from METEOSAT visible imagery. Standardized monthly charts of albedo, on the scale of the PERIDOT and MESO models, have been used operationally since May 1986. Simulations of the state of the atmosphere are being undertaken for particularly interesting days of the HAPEX MOBILHY experiment. This experiment is being conducted in south-western France and is intended for modelling the water balance on the scale of the mesh of a model of the general circulation.

3. Semi-operational use of the surface visible flux

Semi-operational use has been instituted, enabling the surface visible solar flux, of which the surface albedos are a by-product, to be obtained. The solar flux calculated from each visible image, corrected for Cosθ and for atmospheric effects, is then integrated over a period of 3 hours and then over a period of half a day. Maps of fluxes showing the zones represented by a certain number of stations, successively, in the morning, in the afternoon and over the whole day are being prepared.

4. Use of satellite data for estimating the w ter balance

In 1986 a study was commenced on deriving arameters associated with evaluating the water balance from the AVHRR data c NOAA satellites. These data were collected during the period of intensive observations (spring 1986) of the HAPEX- MOBILHY campaign. They are subjecte to pre-processing, essential for obtaining multi-temporal composite i ages, before being archived. The parameters studied are: the type o dominant surface, the vegetation index, and the surface temperature and ts diurnal variation. The aim is to introduce these parameters in the parameterization of mixtures at the interface in the model at present developed in the Centre national de recherches météorologiques (CNRM).

In order to produce composite charts of vegetation indices it was necessary to make a correction for effects associated with the geometry of sighting and degree of illumination and also atmospheric effects. An algorithm for correction has been studied and series of images are at present under study. A classification of surfaces has been undertaken by means of the parameters: vegetation index and radiometric brilliancy and temperature. We would point out that the evaluation of surface temperature necessitates an estimate of the emissivity of the ground surfaces and an estimate of the term for correcting for atmospheric effects. A simulation of the correction terms, obtained for different types of atmosphere and for different values of the emissivity, has been undertaken.

5. Atmospheric movements deduced from ozone fields

Maps of total ozone are deduced from TOVS infrared radiances. A spatial resolution of about 50 km and a temporal resolution of 6 hours (two satellites twice per day) enables the small-scale structures to be monitored. Validation has been undertaken over the European zone enabling the deduced winds at 100 hPa to be assigned; the mean value is 13 ms^{-1}, the standard deviation is 8 ms^{-1} and the error of estimation is 7 ms^{-1} (30 days in September). Global measurements have been made; about 80 such measurements can be made per day, and per hemisphere. A second validation campaign is being started which, if successful, will be followed by a study of the impact of these measurements of wind by satellite of the analyses of meteorological models (ECMWF).

GERMAN DEMOCRATIC REPUBLIC

PART I Summary of highlights

Theoretical studies in remote sounding were focused on remote temperature sounding by means of partial interferograms. Systems for digital satellite pictures are under development.

PART II Research and development

Theoretical studies in remote sounding were focused on remote temperature sounding by means of partial interferograms. 'possibly the last significant thrust of passive radiometry for atmospheric sounding'. The results stress the importance of an adequate knowledge of line absorption of other absorbers than CO_2 in the 15 µm region, especially of water vapour (SPÄNKUCH, GÜEDNER and DÖHLER, 1987).

In order to minimize retrieval errors of meteorological parameters from satellite measurements the IAMAP Radiation Commission has organized an International Transmittance and Radiance Algorithm Intercomparison called ITRA. The activities of the nadir subgroup were coordinated by D. Spänkuch from the Main Meteorological Observatory Potsdam of the Meteorological Service of the GDR. Six leading international groups participated in the ITRA quasi-nadir geometry intercomparison. Although the same model atmospheres and spectroscopic input data were used the discrepancies were up to 10 % in transmittances and more than 2 mW m^{-2} sr^{-1}/ cm^{-1} in radiances equivalent to about 2 K differences in brightness temperatures for the 15 µm TOVS channels. The discrepancies caused about half by incorrect knowledge of spectroscopic effects (form of far line wings, line interference, etc.) and half by using different numerical algorithms are larger for high spectral resolution values. The analysis is in progress. Comparisons of line-by-line calculations with measured ones for homogeneous conditions indicated for the 15 µm CO_2 band system some incorrectness in band intensities of some transitions and of half-widths as well of the necessity of considering line interference effects (DÖHLER and SPÄNKUCH, 1984). Present data sets do not give the answer which of the existing line data can be declared as the optimum spectroscopic set (SPÄNKUCH et al. 1984, 1985).

PART V Future operational systems

A project for receiving and processing digital weather satellite pictures is being carried out in co-operation of the German Democratic Republic and the Socialist Republic of Rumania. That includes systems for the Democratic People s Republic of Korea and for the Meteorological Service of the GDR

PART VII Publications

Döhler, W.; Spänkuch, D.: 1984, New comparison between measured and calculated CO_2 transmittances in the 15 µm region for homogeneous conditions. In: Fiocco, G. (ed.): IRS'84: Current problems in atmospheric radiation. A. Deepak Publ., Hampton, VA, USA, 403 - 409

Spänkuch, D.; Döhler, W.: 1985, TOVS transmittances: Is there an optimum spectroscopic data set? Techn. Proc. 2nd Intern. TOVS Study Conf. Igls, Austria, 18 - 22 Febr. 1985 Coop. Inst. Meteorol. Satellite Studies, Madison, Wisconsin, Sept. 1985, 254 - 259

Spänkuch, D.; Döhler, W.; Güldner, J.: 1984, Comments on TOVS transmittances. Techn. Proc. First Intern. TOVS Study Conf., Igls, Austria, 29.8. - 2.9.1983 Ed. W. P. Menzel, Coop. Inst. Meteorol. Satellite Studies, Madison, Wisconsin, March 1984, 279 - 284

Spänkuch, D.; Güldner, J.; Döhler, W.: 1987, Investigations on temperature soundings using partial interferograms Beitr. Phys. Atmos. (1987) (in press)

GERMANY, FEDERAL REPUBLIC OF

Deutscher Wetterdienst, Offenbach

PART I SUMMARY OF HIGHLIGHTS

The method for manual generation of vertical profiles of the relative humidity for the numerical analysis (BOGUS data) on the basis of IR and VIS satellite images has been in operational use since mid October.

The method for computation of the global irradiance from METEOSAT images was tested for nearly every month of the year and led to good results when verifying the monthly averages and to satisfactory results when verifying the daily totals.

PART II RESEARCH AND DEVELOPMENT

2.1 Humidity BOGUS data

Further tests with this method were performed. The results were encouraging, so that these data are derived once per day for operational use since mid October. A detailed description of the method was published at the 6th METEOSAT Scientific Users Meeting in Amsterdam, 25 to 27 November.

2.2 Global Irradiance

The method for the determination of the global radiation at the ground was tested with METEOSAT data of every month of the year and the results were verified with measurements from 17 stations of the radiation network of the Deutscher Wetterdienst. An example for the monthly totals at Saarbrükken can be seen in table 1.

Days for which too few satellite data were available have been excluded from the computation.

The correlation coefficient for the daily totals of the global radiation at Saarbrücken was 96.6 % for the first 11 months of 1986. For all 17 stations and the whole year the correlation coefficient was about 92 %.

Month	Monthly Average Measurement	METEOSAT	Difference (Measurement -METEOSAT)	Difference in percent of the measurement
1	205	236	-31	15.0
2	609	608	1	0.1
3	768	768	0	0.1
4	1027	1007	20	1.9
5	1656	1581	75	4.6
6	1997	2020	-23	1.2
7	1939	1923	16	0.8
8	1455	1440	15	1.1
9	1211	1241	-30	2.5
10	681	681	0	0.0
11	358	319	39	10.8

Tab. 1: Monthly totals of the global irradiance (J/cm^2) at Saarbrücken

2.3 Estimation of Surface Evaporation using Satellite and Ground Based Data

On the basis of TM-data and a geocoded information system, containing information on soil properties, elevation, slope, aspect and meteorological data, a model is developed with the aim to estimate surface evapotranspiration on a high spatial and temporal resolution basis. The study area lies within a highly inhomogeneous agricultural region in Central Europe. The 30-m resolution TM-data will be used to estimate land use, degree of ground cover, plant development stage and the distribution of soil types. METEOSAT-data will be used to estimate the degree of ground cover.
(W. Mauser, M. Weghenkel)

2.4 Derivation of Plant Parameters from Air-Borne Synthetic-Aperture RADAR Data

Plant and soil parameters (plant height, aerodynamic roughness, plant density, soil moisture) are vital parameters for the determination of interception, infiltration and evapotranspiration. Digital air-borne synthetic-aperture radar (SAR) data of an agricultural test site in the Rhine Valley are used to compare the information contained in the SAR data with ground-truth gathered of numerous fields

during the growing season. Regression constants for the determination of the dependency of the RADAR backscattering signal on aerodynamic roughess or soil and plant moisture are derived as a preparatory study for the use of the RADAR-data, that will be gathered by ERS-1 in the 1990's.
(W. Mauser)

2.5 Estimation of Chlorophyll- and Sediment Concentration and Surface Temperarture of Lake Constance Using Remote Sensing Data

Within the framwork of the Research Task Force "Dynamics of great pre-alpine Lakes" sponsored by the German Research Foundation investigations are conducted on ways to use TM and NOAA data for the determination of the spatial distribution of chlorophyll, sediment and surface temperature of a great lake in Southern Germany. The main emphasis of the study is to determine, together with other groups (e.g. Limnological Institute, University of Constance), whether satellite data can be used to investigate the spatial and temporal dynamics of the plankton distribution and the variability of evaporation of a great lake. Preliminary results on the correction of the influence of the atmosphere on the sensor signal and the determination of chlorophyll and sediment distribution have already been obtained.
(W. Mauser, B. Grunwald, K. Schneider)

2.6 Positioning of a coastal gauge through GPS

The roughly 40 gauges on the German North Sea and Baltic Sea coasts are every 15 - 20 years checked connected with main levellings with the German network of main elevations and the elevations of the gauge bench marks, related to mean sea level. At specified time intervals (usually every 2 years) the gauges are positioned and controlled from at least three gauge bench marks. If the elevation of a gauge has changed by more than 2 cm, the gauge datum is corrected. The water levels measured change accordingly and it is often difficult, in considering and evaluating water level series of the past, to determine and take into account, if possible at all, the data from which the change occurred. It has to be added that gauges and gauge bench marks are spatially close to one another. A change in the elevation of the gauge often corresponds also to a change in the elevation of the bench marks of the same tendency.

It was natural to position coastal gauges through NAVSTAR-Global-Positioning-System (GPS). The advantage of a GPS measurement is that for all gauges a homogeneous elevation reference system can be achieved because measurements can be continuously performed within a few days and based on underground bench marks considered to be tectonically safe.

As a first step a GPS measurement was carried out by the Federal Institute of Hydrology at Koblenz to correlate the Helgoland gauge with the continental system. Four V-1000 macrometers of the firm GEOsat, Mülheim, were used.

In evaluating, also the varying troposhperic data are taken into account. The results obtained so far are all within the expected range of accuracy of 1 ppm. From the vectors, the ellipsoidal differences in elevations can be read, for the transition to msl elevations, decisions as to the assignments of geoid and ellipsoid must be taken. This is difficult on the basis of existing geoid models since geoidal differences in elevations of up to 1.75 m between continental and Helgoland gauges must be expected on the basis of existing quasigeoids.

In evaluating, optimization on the basis of available data is sought. In any case the elevations obtained ellipsoidally are taken as a basis for the future checking of gauges for spatial variations.

The positioning of coastal gauges via GPS is designed to be continued. For the assessment of recent water level fluctuations of the North Sea, controls at intervals of 3 - 5 years are provided. (Meiswinkel)

2.7 Estimation of Convective rainfall volumes with the aid of satellite data

The scarcity of hydrometeorological ground data for design and operation of water resources systems in remote and developing areas is usually a problem. A method for estimating rainfall in these areas based on data derived from geosynchronous satellite imagery will be developed. For the estimation of half-hourly rain volumes of convective cells with the aid of METEOSAT infrared data the following parameters

can be used: (a) cloud-top temperature, (b) the half-hourly rate of change of this temperature, (c) size of cloud area defined by a distinct temperature threshold, and (d) the rate of change of this area with respect to time. Preliminary results obtained by means of various regression equations connecting the above mentioned remote sensing data with simultaneously observed ground truth of a test area comprising the south of Germany already exist.
(L.-R. Krüger, R. Harboe & G. A. Schultz)

2.8 Estimation of monthly river runoff data on the basis of satellite imagery

For the generation of long time series of hydrological design data, e.g. monthly runoff values, a method is presented using information obtained from the NOAA Polar Orbiting Satellite System. This method consists of four consecutive steps, namely: (a) satellite remote sensing data processing, (b) development and calibration of a mathematical model, which correlates measured runoff values (ground truth) with satellite data, (c) generation of long monthly runoff time series on the basis of satellite data alone, and (d) by means of a stochastic model and the time series computed under (c): simulation of synthetic runoff time series, which are long enough to meet the requirements of a potential application. First results of the application of this method in a basin in southwerstern France exist already. (G. Strübing & G. A. Schultz)

PART III TECHNIQUES DEVELOPMENT

3.1 TOVS

In cooperation with Deutsche Forschungs- und Versuchsanstalt für Luft- und Raumfahrt (DFVLR) an experiment for retrieving TOVS data, was performed. The retrieval was performed at DFVLR, verification was done at the Deutscher Wetterdienst by comparison of the retrieved profiles with radiosonde data. As the TOVS Export Package Version No 2 was used estimates of the temperature and moisture profiles were required as input data. In this experiment climatological data had been used.

The results of this experiment were unsatisfactory because of the differences between the climatological input data and the actual data of the test period. It is planned to repeat the test with more realistic input data taken from the numerical analysis or numerical forecast.

In future it is intended to retrieve TOVS data by using the Export Package Version No 3.

PART IV OPERATIONAL SATELLITE DATA APPLICATIONS

4.1 Central Image Processing System at Offenbach

The are no significant changes as against the previous reports. As an additional information system and as backup system in case of a breakdown of the processing system for the digital METEOSAT data, a SDUS has been installed at RAFC Frankfurt.

4.2 Local and Regional Image Reception and Processing

The installation of SDUS at regional meteorological offices and aerodrome meteorological offices for the reception of METEOSAT images has been continued so that now 16 offices have own facilities for the reception of satellite images.

4.3 DCP

Several DCP units are in operation in the coastel area and on board of ships:

- a moored oceanographical buoy in the North Sea at 55°N, 6°, operated by Deutsches Hydrographisches Institut (DHI);
- an automatic station in the Lighttower of Kiel;
- two mobile units on board of fishery protection vessels, cruising normally in the North Atlantic, transmitting SYNOP and TEMO data;
- an automatic weather station at the antarctic Georg-von-Neumayer station, operated by the Alfred-Wegener-Institut for polat research in Bremerhaven, transmitting SYNOP and TEMP data;
- one unit on board of the polar research vessel "Polarstern", transmitting SYNOP and TEMP data.

PART V PLANS FOR FUTURE OPERATIONAL SYSTEMS

5.1 Central Image Processing System at Offenbach

A new satellite data reception and processing system will be installed in 1988 to replace the old system.

It will consist of

- the PDUS which has been already available since 1978
- a HRPT receiving station
- a dedicated computer system for preprocessing
- an interactive graphical system (IGS) to display satellite and conventional data.

This system will be connected to the main computing centre via suitable data links.

It is intended to put the methods into operational applications which are currently still under development and tests, i.e. incident solar radiation, BOGUS moisture and TOVS data retrieval. AVHRR data will be processed to provide supplementary information, i.e. cloud analysis, sea and land surface temperatures, snow maps, etc.

5.2 Local and Regional Image Data Reception and Processing

Four local and aerodrome meteorological offices are planned to be equipped with an SDUS in 1987.

5.3 Estimation of parameters of hydrological models on the basis of satellite data

Using multisensor and multispectral satellite data and geo-integrated information systems the catchment parameters used in distributed system models are estimated. LANDSAT-TM and -MSS, Radar and SPOT data are used to identify landuse, soil and surface data to predict runoff characteristics in medium catchment areas and the influence of urbanization changes. (P. Neumann & G. A. Schultz)

PART VI VERIFICATION OF OPERATIONAL PRODUCTS

6.1 Cloud Motion Vectors

Cloud motion vectors derived at the European Space Operation Center were compared with radiosonde winds. The results for the period February to July 1986 are listed in Table 2.

During the last years a considerable improvement in the quality of the cloud motion vectors was recognized, however, there are still some problems in the height assignment. This can be seen when comparing the cloud motion vectors with the radiosonde winds in the level of best fit. The pressure difference between assigned height and level of best fit is an indicator for the quality of the height assignment. Table 3 shows that there is an improvement in the height assignment but it is not as significant as in the vector difference e.g.

Level:	SFC-700 hPa	699-400 hPa	399 hPa-TOP
Direction Dif. (°)			
mean abs.	24.1	19.5	18.8
RMS	37.3	30.7	31.6
Speed Dif. (m/s)			
mean alg.	- 0.5	1.2	3.0
RMS	4.3	7.2	10.1
Vector Dif. (m/s)			
mean abs.	4.8	6.6	9.1
RMS	6.0	9.1	13.1

Tab. 2: Comparison radiosonde/METEOSAT wind for the period February - July 1987

	1983	1986
Direction Dif. (°)		
mean abs.	22.8	11.6
RMS	37.7	19.8
Speed Dif. (m/s)		
mean alg.	- 2.0	0.2
RMS	9.1	4.5
Vector Dif. (m/s)		
mean abs.	9.4	4.7
RMS	13.1	6.0
Press. Dif. (hPa)		
mean alg.	12.1	12.1
RMS	137.2	120.1

Tab. 3: Comparison radiosonde/METEOSAT wind (upper-level) in the level of best fit for the period February - July 1983 and 1986.

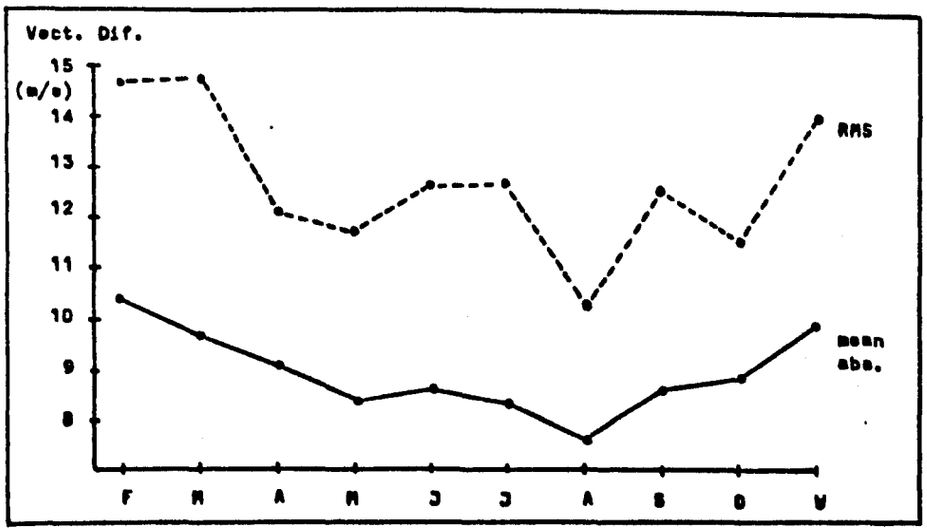


Fig. 1: Vector Difference (m/s): Radiosonde wind (assigned height of METEOSAT wind) - METEOSAT, February - November 1986, upper level

As illustrated in figure 1 there are fluctuations in the quality of the cloud motion vectors from month to month.

PART VII OTHER ITEMS

7.1 References

Benesch, W.; Kaestner, A.:
Improvement of the Numerical Humidity Analysis by Subjective Interpretation of METEOSAT Images. The Sixth METEOSAT Scientific User Meeting, Amsterdam, 25 - 27 November 1986, European Space Agency.

7.2 Publications

Benesch, W.; Paetzold, K.:
Nutzung von METEOSAT-Daten für die Wettervorhersage im Deutschen Wetterdienst. In: Fernerkundung und Raumanalyse. Klimatologische und landschaftsökologische Auswertung von Fernerkundungsdaten. Wilfried Endlicher/Hermann Goßmann (Hrsg.), Herbert Wichmann Verlag, Karlsruhe, 1986, S. 177 - 197

Kurz, M.; Benesch, W.:
Hinweise zur Interpretation von Satellitenbildern. Teil 1: Interpretation von Satellitenbildern für Zwecke der Luftfahrt, Selbstverlag des Deutschen Wetterdienstes, Offenbach am Main, 1986

HONG KONG

Royal Observatory

PART I SUMMARY OF MAJOR HIGHLIGHTS OF RESEARCH APPLICATIONS AND OPERATIONAL CHANGES

1.1 High resolution imageries (HR Fax) from the Japanese Geostationary Meteorological Satellite (GMS) and the Automatic Picture Transmissions (APT) from the NOAA satellites were received operationally.

1.2 SATOB's and SATEMP's were received from Tokyo via GTS and were used in upper air analysis.

1.3 Since June 1984, SAREPs on tropical cyclones were issued by the Japan Meteorological Agency as part of the Post-TOPEX activities among East Asian countries. These messages were received via the GTS and were used in the determination of tropical cyclone centres.

1.4 A video movie of the animated satellite imageries of Typhoon Wayne (8614) was produced.

1.5 There were no major operational changes in 1986.

PART II MAJOR RESEARCH AND DEVELOPMENT IN THE APPLICATIONS OF SATELLITE DATA

2.1 Precipitation Forecasting

Investigation has been undertaken to correlate precipitation rate associated with summer monsoon and tropical cyclones in the south China coastal areas as measured by radar with albedo and temperature at cloud top as referred by GMS HR imageries. Results indicated that only cloud top temperature and albedo were not sufficient to determine the precipitation rate associated with summer monsoon and tropical cyclones in this area.

PART III TECHNIQUE DEVELOPMENT

3.1 Integrated display of satellite imageries and simultaneous Earth-based observations

Software has been developed to display GMS HR imageries and fields of selected Earth-based observations including surface, upper, radar reports, on graphic terminal for operational use. This will enable the forecaster to visualize the 3-dimensional structure and movement of weather systems.

3.2 Overlay for APT imageries

Program has been developed to generate overlay of latitude/longitude grids and coastline for NOAA APT imageries from the TBUS messages.

PART IV DESCRIPTION OF SYSTEM IN OPERATIONAL USE

4.1 A block diagram of the meteorological satellite ground reception system is shown in figure 1.

4.2 A 5 m diameter parabolic antenna and a microwave receiver pick up the HR signals which, after demodulation and digitization, are recorded on a 9-track computer tape.

4.3 The brain of the system is the Weather Image Processor (WIP) which is based on several Z80 microprocessors. By means of the WIP, the brightness level of cloud features can be enhanced according to different Look-up Tables (LUTs) for detailed study.

4.4 The WIP and the video monitor also enable 16 pictures to be shown in an animated sequence.

4.5 Both infra-red and visible cloud images can be produced at different magnifications either in photo-fax copies or in digital computer printouts. Pictures produced by the facsimile recorder are in 16 shades of grey.

PART V PLANS FOR FUTURE OPERATIONAL SYSTEMS

5.1 The new GMS reception system for the planned digital GMS to be launched by Japan in mid-1988, will be procured.

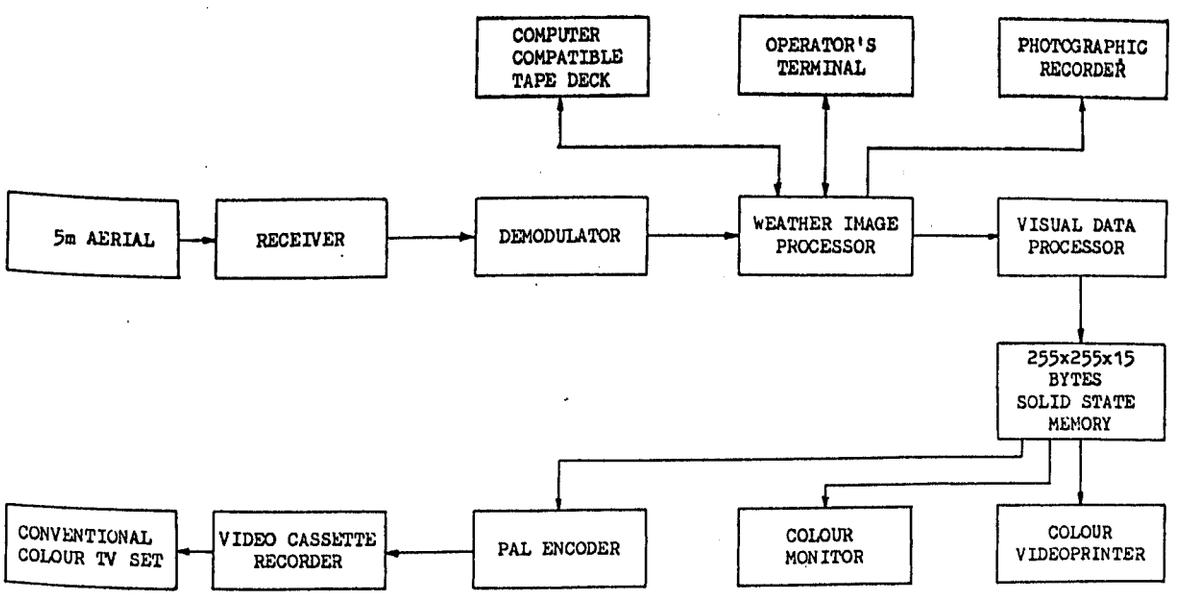


Figure 1. The meteorological satellite reception system used by Royal Observatory, Hong Kong.

HUNGARY

Meteorological Service of the HPR
Budapest

PART I

SUMMARY OF HIGHLIGHTS

In 1986 four SDUSs were installed at different units of the Meteorological Service /Central Forecasting Institute, Ferihegy Airport, Storm Warning Observatory, Siófok and Hail Suppression Center in South Hungary/ for receiving METEOSAT WEFAX transmissions. The microprocessor based processing system connected to the SDUS permits to carry out a digital evaluation of satellite imagery and consequently a manifold analysis of cloudiness /including the study of the temporal variations, the movement and evolution of clouds/. The mode of processing is to be chosen by the operator and the results are presented by a colour display unit.

PART II

RESEARCH AND DEVELOPMENT IN THE APPLICATIONS OF SATELLITE DATA

The joint display of meteorological fields and satellite imagery has been realized using a graphical display unit. The method is based on the bilinear interpolation of the grid point data and it comprises the stereographic projection of the two kinds of information on maps /D. Dévényi/.

The elaboration of an objective cloud analysis techniques has been started for METEOSAT images. A brightness smoothing program was developed standardizing the visible data to a 45° elevation of the Sun. The main objective was the determination of the total cloud cover. We tried to find the solution for cases when cloudiness only partially covers the pixels /T. Tänczer/.

An attempt was made to estimate the hourly values of global radiation reaching the Earth's surface using METEOSAT imagery. The difference between the calculated and observed values was greater as compared to the estimation of daily totals /A. Rimóczi-Paál/.

Using the empirical formulae received for the territory of Hungary it was attempted to calculate the values of solar radiation reaching the Earth's surface for the territory of Central and Southern Europe. As proved by a comparison with 70 surface stations, the mean error did not exceed 5 to 6 per cent /A. Rimóczi-Paál/.

The adaptation of the program pack provided for the evaluation of TIROS Operational Vertical Sounder data has been started /M. Putsay/.

Studies were continued in order to identify different plants and to determine their state. The recognition program system based on learning algorithm used so far has been improved. Winter wheat was highlighted in this connection in the relevant investigations /P. Bozó and V. Vadász/.

PART III

TECHNIQUES DEVELOPMENT AND APPLICATIONS

In 1986 a mobile analogue satellite data receiving and processing system with microprocessor /METEODATA-2/ was developed in Hungary for WEFAX transmissions. The receiving and processing procedures can be freely programmed. The video-signals received in this way are displayed on TV or on a professional monitor. The system can comprise 30 image levels at a maximum. It is possible to store the images by normal tape recorders.

The field of application of the system widens considerably if coupled with a microcomputer /e.g. projection transformation, compilation of loop-movies, special image processing procedures etc./.

Simultaneously the experimental operation of the image processing subsystem of the PDUS/HROP station to be established has been started. The main units of the subsystem are: TPA-1148 computer with a 2 Mbyte CPU, a 380 Mbyte backing store, magnetic tape recorders, printers, special image display and processing units. The technical test of the PDUS receiver has been started /F. Pintér/.

PART IV

SATELLITE APPLICATIONS IN OPERATIONAL USE

The most important users of satellite data are the forcasting services. A whole series of information enhancing procedures can be carried out with the WEFAX images. The procedure of processing is chosen by the meteorologist depending on the actual synoptic situation. The most frequent procedures are:

1. geometrical corrections of satellite imagery,
2. magnification of the territory of the Carpathian Basin,
3. estimation of cloud top temperature values,
4. determination of the horizontal extension of clouds or cloud systems,
5. inter-image algebraic procedures,
6. calculation of the displacement of a frontal cloud band,
7. extrapolation of the field of clouds,
8. compilation of loop-movies based on observations lasting several hours,
9. joint display of satellite and radar data,
10. presentation of linear and alphanumeric data on satellite images /F. Pintér/.

Due to that kind of satellite application the quality of weather analysis has significantly improved positively affecting the reliability of the forecasts as well.

PART V

PLANS FOR FUTURE OPERATIONAL SYSTEMS

A computer controlled complex /radar, satellite and conventional/ mesoscale information management system is to be mentioned here as a basis for a nowcasting-type warning system. The joint presentation of satellite images and standard meteorological charts /surface synoptic charts, topographies/ by a display unit is planned for the operational service. It is intended to enhance the application of satellite data in precipiation forecasting as well. The adaptation of the Scofield method to Hungarian conditions in going on /Á. Takács/.

The completion of the PDUS/HRPT receiving system now under construction and its connection to the processing system is expected in this year.

PART VI

VALIDATION AND VERIFICATION OF SATELLITE DATA

In the course of satellite cloud climatological investigations a study of the β -distribution in seasonal arrangement was carried out using the European data base of total cloud cover. As a result the main patterns of distribution over Europe were determined. In order to study the comparability of the two kinds of data bases and to verify the reliability of the satellite data base the study was repeated using the data series of total cloud cover received by surface observations of 30 years. The results proved the comparability of the two kinds of information.

PART VII

NAMES AND ADDRESSES OF THE HUNGARIAN SCIENTISTS IN CHARGE

Bozó, P.:	Central Forecasting Institute H-1675, Budapest POB 32.
Dévényi, D.:	Central Forecasting Institute H-1675, Budapest POB 32.
Kapovits-Róth, R.:	Central Meteorological Institute H-1525, Budapest POB 38.
Pintér, F.:	Computer Center of National Meteorological Service, H-1675, Budapest POB 32.
Putsay, M.:	Central Forecasting Institute H-1675, Budapest POB 32.
Rimóczi-Paál, A.:	Central Institute for Atmospheric Physics, H-1675, Budapest, POB 39.
Takács, Á.:	Central Forecasting Institute H-1675, Budapest POB 32.
Tänczer, T.:	Central Forecasting Institute H-1675, Budapest POB 32.
Vadász, V.:	Central Forecasting Institute H-1675, Budapest POB 32.

INDIA

India Meteorological Department

Part I: A brief summary of the major highlights of research applications and operational changes

During the year 1986 the meteorological data received from INSAT-1B was utilised for providing support to operational cyclone tracking, for monitoring various phases of the activity of southwest monsoon and for meteorological analysis and forecasting. An important application of the satellite data started during this year is the issue of short term heavy rainfall advisories for the periods of 6 to 12 hours to the field forecasting offices for the whole of India. Efforts have also been made to monitor the snow cover over the Himalayan rivers basins using NOAA satellite imagery, for utilising this information in weather forecasting and water management.

Part II: A description of the major research and development in the applications of satellite data derived products and services

(i) Monitoring the snow cover in the river basins:

AVHRR pictures received from NOAA meteorological satellites in the visible and infra-red channels during 1984-86 are being used for mapping the snow cover over the catchment areas of some of the Himalayan rivers on a research mode. Prediction techniques for snow melt run-off in various catchments during the summer season are under development.

(ii) Studies have been initiated into the fluctuations of Inter-Tropical cloud band with a view to investigating the nature of monsoon surges. Systematic and steady northward advances of the cloud zone is related to the advance of monsoon during the month of June.

Part III: A description of technique development and applications of satellite data, derived products and services

(i) Monitoring and estimation of heavy rains:

India gets most of its rain during the monsoon season. Extensive and intensive precipitation occurs in association with well defined pressure perturbations such as monsoon depressions and active low pressure areas. Heavy continuous rain generally falls from deep stratified clouds with embedded

convection. The growth and movement of the cloud pattern derived from geostationary satellite imagery provides a useful indicator for predicting short period heavy rainfall trends. Work is in progress for development of models for estimation and prediction of heavy rainfall based on INSAT-1B data. Synoptic climatology of various important rain-storm situations are also being examined.

(ii) Cloud data are analysed in the visible and IR channels using interactive image processing facilities available. The cloud top temperatures are monitored in regions of interest. Both SSTs and CMVs are derived on routine basis. CMVs have been used for identifying overshooting cloud tops. These also find applications in the assessment of heavy rains.

(iii) Daily and weekly precipitation estimates are being carried out over an area extending from latitude 35°N to 25°S and Longitude 40°E to 100°E for each box of 2.5° Lat/Long. on an experimental basis. Weekly satellite derived rainfall maps for the meteorological sub-divisions over India are being produced. Outgoing longwave radiation (mean) is also being calculated for each of the above box.

Part IV: A brief description of the system for satellite applications in operational use in 1986:

India Meteorological Department is utilising the Indian National Satellite System (INSAT) for providing meteorological support to the operational weather forecasts. It is a 3-axis stabilised geostationary satellite stationed at Lat. 74°E over the equator. Earth cloud cover data are provided by utilising very high resolution radiometer (VHRR) operating in the visible and infrared channels at a resolution of 2.75km in the visible and 11.0km in the infrared channels. The system is designed to provide half-hourly data for the full earth disc alongwith sector scans for limited areas once every six minutes.

One hundred receivers of the Disaster Warning System (DWS) have also been commissioned in two southern coastal states for direct reception of warning about the natural disasters due to cyclones etc. These warnings will be disseminated by a central earth station and will help in taking timely action against the impending disasters.

INSAT-1B imagery is now available in near-real time at 20 Secondary Data Utilisation Centre (SDUC) locations in the forecasting offices of the country.

Part V: Plans for future operational system of satellite applications to meteorology and operational hydrology

The INSAT Meteorological Applications Programme which is operational since October, 1983 is now in its fourth year of operational service. This will continue with the launch of INSAT-1C in early 1988. A fourth satellite, INSAT-1D, is also planned so as to ensure availability of the requisite space-segment capability and capacities during the transition from the first generation INSAT-1 to the second generation INSAT-2 in the early 90s.

Part VI: Validation and verification of satellite data and derived products used in operations including performance statistics:

This will be taken up in the near future.

Part VII: Other items (references, publications and the names of scientists incharge etc:

1. Mishra D.K. & B.K. Basu, 1987; "Wave pattern observed in cellular clouds over the Arabian Sea", Mausam 1987 Vol. 38 No. 1, pp. 119-122.

2. Agnihotri C.L. & M.S. Singh, 1987;"Absorption of short waves radiation in the atmosphere over India in winter", Mausam 1987, Vol. 38, No. 1, pp. 79-84.

3. Agnihotri C.L., 1986; "Inferences of the moisture field over Arabian Sea during the monsoon of 1984 using INSAT-1B sea Surface temperature data", Mausam, Vol. 37, No. 4, pp.521-524.

4. Mishra D.K., S.K. Pradhan, A.P. Johri, N.Y. Apte, D.K. Misra, & A.K. Srivastava, 1986;"Snow cover over Beas catchment" Vayu Mandal, Vol. 16 No. 3&4.

5. Kelkar R.R. & P.N. Khanna, 1986;"Automated extraction of cloud motion vectors from INSAT-1B imagery" Mausam Vol. 37, No.4, pp. 495-500.

6. Veeraraghavan K.,"INSAT data collection system" Vayu Mandal(in press)

JAPAN

PART I - A brief summary of the major highlights of research applications and operational changes

An Estimation of Precipitation Intensity from GMS Data by Using Digital Radar Echo Intensity

In order to estimate the precipitation intensity from GMS data, the relationship between the digitalized GMS data (visible and infrared) and the digital radar echo intensity data was investigated. The visible channel data were strongly correlated with the radar echo intensity data, however the infrared channel data were weakly correlated with.

16 data sets occurred in summer season around Japan in 1985 were prepared. We tested an new precipitation estimation technique based on the least-squares multivariate linear regression (third order polinominal expression of infrared and visible data). The correlation coefficient between the estimates and the digital radar echo intensities was 0.69 on average.

Regression coefficients made by certain time data in this data series were applied to another data sets and evaluated by correlation coefficient. The average of correlation coefficients was 0.66.

(S. Osano, T. Motoki, K. Suzuki ; Meteorological Satellite Center)

PART II - A description of the major research and development in the applications of satellite data, derived products and services

The prediction experiments of the Asian summer monsoon by use of the global spectral model with heat source estimated from the satellite-cloud data. (K.Kuma)

The mechanism of the onsets of the Asian summer monsoon over South-East Asia as well as India is studied by use of JMA global spectral model. It has been reported that there are usually two transition periods during the early stage of the monsoon. These two transitions correspond to the onsets of South-East Asian monsoon and Indian monsoon respectively. The movement of the anticyclone in the upper troposphere over the south Asia can characterize these transitions. Therefore, it is very important to understand the mechanism of the behavior of this anticyclone. Gill(1980) suggests that the monsoonal circulation could be regarded as the Rossby wave response to the heating over the tropical region with his linear shallow water equation.

Using nonlinear full model, we perform the prediction experiment for two transition periods in 1986 with and without the heat source, which is estimated from the cloud top temperature observed by Japanese Geostationary Meteorological Satellite. The heat source is given over the domain from 30°S to 30°N and 90°E to 170°W.

In this experiment, we can find that the tropical heat source plays an important role in generating the anticyclone at 200mb. Therefore, we investigate the behavior of the tropical heat sources, which can be roughly represented by the divergent field at 200mb. The center of this divergence, analyzed in JMA, clearly moved eastward with the period of 40 days in May and June of 1986. When this divergent field at 200mb came over the Indonesian region, the anticyclone over the south Asia was rapidly intensified. This result suggests that the eastward moving mode over the tropics should trigger the development of the Rossby mode over the monsoon region, which brings about the beginning of the rainfall, that is, the onset of the monsoon.

Improvement of the estimation scheme for dew point depression using GMS data (A. Baba)

Using equivalent black body temperature (T_{BB}) data retrieved from GMS (Himawari) infrared radiation observations, we estimated vertical profiles of dew point depression(T-TD) and used them in the routine humidity analyses. The GMS T_{BB} data include the information about the cloud condition on a 1°x1° latitude/longitude grid over the area 50°N-50°S, 90°E-170°W. With the T_{BB} data, we can objectively estimate the cloud conditon on every 1°x1° grid. We assume a vertical humidity profile as a function of the cloud condition. In routine humidity analysis, we used the estimated data of T-TD only on every 2°x2° latitude/longitude grid over the ocean. The impacts of them on the operational numerical weather forecast have been examined in some cases.

Recently we have improved the T-TD estimation scheme. The revision were mainly made in the following four points; (1) the method of the determination of cloud type, (2) the assumed vertical humidity (T-TD) profiles, (3) the utilization of synoptic observations, (4) the classification of the estimation scheme for the tropical region and the subtropical region. With the revised scheme, the relation between the humidity analysis and the cloud distributions has become more realistic.

An Investigation of the Large-scale Cloudiness Changes over the Monsoon Area (M. Murakami)

By utilizing the Artificial Satellite Data Analysis System (ASDAS) in the Meteorological Research Institute (MRI), a technique has been developed to merge both Indian INSAT and Japanese GMS geostationary satellite imageries. It enabled us to investigate the large-scale cloudiness distribution and its change more efficiently over the wide area ranging from the eastern Africa through the central Pacific. A preliminary study performed during the northern hemispheric summer monsoon season in 1985 has proved its usefulness for tracking the large-scale behavior of the cloudiness change associated with the monsoonal fluctuations. It turned out to be especially helpful to investigate the east-west oriented convective cloud band ranging from the Arabian Sea to the western Pacific. A more comprehensive investigation has been proposed as a part of the co-operative project between Japan and India.

PART III- A description of techniques development and applications of satellite data, derived products and services

Rain area delineation using the split window measurements (T. Inoue)

Brightness temperature difference between the split window measurements (BTD) is a good information to identify whether the cloud is optically thick or thin. An objective technique of cloud type classification over the tropical ocean has been developed using the diagram of 11 μm brightness temperature and BTD. By inspection of the corresponding nephanalysis chart, it is found that cirrus , cumulus and cumulonimbus clouds are classified well by this technique.

Cumulus and cumulonimbus cloud areas that are classified by the technique are compared with the concurrent radar rain area. For convective case, the radar rain area corresponds well with the cumulus or cumulonimbus cloud area. Further study is necessary for the estimation of rainfall rate.

PART IV - A brief description of the system for satellite applications in operational use in 1986

Application to marine meteorological data collection of in situ observations

JMA has plan to set some SEAS units on board marine meteorological observation ships and merchant ships. The SEAS unit equipped on board the observation ship KEIFU MARU of JAPAN METEOROLOGICAL AGENCY will come into operation from March, 1987. KEIFU MARU will send the data of marine meteorological, upper aerological and bathy data to JMA through GMS 'HIMAWARI'.

One of the observation ship of JMA,CHOFU MARU has been equipped with DCP system for sending the data of marine meteorology and so on, and will send the data to JMA through 'HIMAWARI' from March, 1987.

PART V - Plans for future operational systems for satellite applications to meteorology and operational hydrology.

A. New Computer System and Products on Meteorological Satellite Center

I. New Computer System

The computer system being used at Meteorological Satellite Center (MSC) at present was established in April 1977.

The new computer system was installed at MSC in September 1986, and then various kinds of check-out of the system has been done to validate the performance of the new computer system with intermittence of VISSR observations, until full operation of the new computer system starts in March 1987. The conceptual illustration of the new computer system is shown in Fig. 1.

The new computer system consists of four main frames. They are primary and secondary satellite control/operation system, or on-line and batch image data processing system.

The new computer system has a very large mass storage equipment which can be accessed commonly from any of the four systems and enables inter-system communication and data exchange.

I-1. On-line Image Data Processing System

The host computer of this system is FACOM M-380S. Principal peripheral equipments of the system are a magnetic tape unit with 2 tape drivers, a line printer and a high-speed communication control processor (HCCP), etc.

Main duties of this system are ;

a. Reception of GMS VISSR data and HRPT data of polar orbiting satellites,
b. Calculation of calibration parameters such as temperature and albedo,
c. Generation and transmission of LR-FAX (low resolution facsimile) and HR-FAX (high resolution facsimile) data,
d. Preparation of pre-processed data set of VISSR and HRPT is aimed to transform the original raw VISSR data into a more feasible form for direct access in the batch image data processing system, etc.

In the on-line image data processing system, almost of all jobs are carried out automatically according to a schedule. If there was some anomaly in this system, batch image data processing system would take place as a backup system.

1-2. Batch Image Data Processing System

The host computer of this system is another FACOM M-380S. Main peripheral equipments are a magnetic tape unit with 4 tape drivers, two Graphic Displays, 2 sets of man-machine interactive data processing equipments called Image Processing Console (IPC), a cassette magnetic tape unit which controls and drives TV video type cassette magnetic tape up to 10 at one time, a line printer, etc.

Main jobs performed in this system are ;

a. Clear radiance field retrieval,
b. Cloud motion wind derivation,
c. Cloud amount distribution retrieval,
d. Surface temperature field retrieval,
e. Typhoon center location and intensity estimation analysis based on the Dvorak's method,
f. Determination and prediction of the satellite's orbit and attitude,
g. Vertical profile retrieval of temperature and water vapor using TOVS data of NOAA series satellites.

2. Principal product changes on the new computer system

2-1. On-line Image Data Processing System

Principal changes in this system are as follows :

(1) LR-FAX images

The formats of the FAX image are changed as follows :

a. Current seven-sectorized pictures for LR-FAX are replaced by four-sectorized pictures. The format of four-sectorized pictures is shown in Fig. 2.
b. Partial pictures, H(infrared), I(visible) and J(enhanced infrared), will be changed : These images are currently only sectorized images covering Japan and contiguous sea area. They are changed to the images with polar-stereographic projection covering Far East area including Japan and contiguous sea. The format of polar-stereographic pictures is shown in Fig. 3.

(2) Basic histogram data

This is a new product. Basic histogram data are calculated three hourly from VISSR infrared or visible data in 0.25°-latitude by 0.25°-longitude boxes. Processed area is from 60 N to 60 S and from 80 E to 160 W. The histogram data are to be used as a basic source data for cloud amount retrieval, clear radiance retrieval, surface temperature retrieval, etc.

2-2. Batch Image Data Processing System

Primary changes in this system are as follows :

(1) Cloud Motion Wind Estimation

Basically the method for low-level cloud motion wind derivation is not changed, that is, the calculation is carried out automatically. The high-level cloud motion wind calculation will be done by the method shown as follows :

a. Automatical procedure : almost the same method as the current method used in the low-level cloud motion wind calculation with change of parameters to choose cirrus level cloud targets.
b. Man-machine interactive procedure : tracking cloud targets man-machine interactively on IPC.

Currently cloud motion wind estimation is being carried out twice a day. In the new system it is to be carried out 4 times a day; at 00Z and 12Z in whole coverage, and at 06z and 18z in the north earth disk. Steering level assignment method is not changed, that is, the low-level cloud motion winds are assigned to fixed level, 850mb, and the high-level cloud motion winds to 200, 250, 300, or 400mb depending upon the season and the latitudes.

(2) Surface Temperature Estimation

In the new computer system, clear radiance field data are retrieved by analyzing the basic histogram data for each 0.25°-latitude by 0.25°-longitude box. And then surface temperature data are retrieved from the clear radiance data with new air mass correction method which incorporates radiative transfer model using objectively analyzed vertical temperature and humidity profile data received from numerical prediction division of JMA. Thus more accurate surface temperature retrieval is expected.

(3) Cloud Amount Distribution Retrieval

High-level, low-level and total cloud amounts are produced in the same way as currently used, but threshold values between the levels are determined using the clear radiance data and vertical profile data described above.

(4) Typhoon Center Location and Intensity Analysis

In the new computer system it is carried out making use of IPC on both infrared and visible images (infrared data are to be main to make daytime and nighttime analyses compatible). The results will be distributed within 30 minutes for center location and 50 minutes for intensity after the observation time.

(5) Satellite Cloud Information Chart

This products are new one improved from the present Nephanalysis Chart and Equivalent Black Body Temperature Contour Chart, and are disseminated in quasi-real-time. This chart will contain the cloud area information which is added automatically and/or man-machine interactively. There are two kinds of products; one covers vicinity of Japan area, and the other Far East area including Western Pacific area, which are called "Vicinity of Japan (VJ) Area Chart" and "Far East (FE) Area Chart" respectively.

The VJ area chart designed to support the local field forecaster is disseminated within 45 minutes after each 3-hourly synoptic observation time to JMA local stations by using land line.

The FE area chart designed to support the aviation field forecaster is disseminated within 50 minutes after each 3-hourly synoptic observation time. The analysis area covers from the equator to 60 N and from 90 E to 170 W. This product will be disseminated to local aviation stations of JMA by using land line.

B. Renewal Plan of the Ground telecommunication Facilities

The GMS ground telecommunication system will be partially renewed in March, 1988.

1. Ground telecommunication facilities

The new system will be improved to perform following functions :

a. to transmit digital formed Stretched VISSR (S-VISSR) signal to MDUS's via GMS-3 instead of current HR-FAX transmission,
b. to be operated almost automatically using computer system, and
c. to record FAX images on film for archiving.

1-1. Command and Data Acquisition Station (CDAS)

Major function of the improved CDAS system are as follows :

(1) S-VISSR signal generation

Detailed illustration of S-VISSR is section 2.

(2) Monitor and Control
The ground system is controlled and monitored by the computer system.

1-2. DPC's Telecommunication system

Major functions of the improved DPC telecommunication system are as follows :

(1) VISSR Interface
S-VISSR data from CDAS are reformatted, decoded and transferred to the main computer system of DPC.

(2) Monitor and Control
The equipments have the following functions :

a. The signals to/from CDAS and the DPC main computer system are monitored and switched,
b. The signals to JMA head office are monitored and controlled, and
c. The system equipments are controlled and monitored.

(3) Image recorders
HR-FAX to be used in DPC and JMA Headquarters and LR-FAX images are automatically recorded on films for archiving.

2. S-VISSR signal generation

The digitalized S-VISSR data of GMS are originated by the VISSR. The original VISSR data received at the CDAS are processed and reformatted, then transmitted with reduced transmission data speed to the MDUS's via GMS whenever the VISSR observation is made. In other words, VISSR observation and re-transmission of the S-VISSR are carried out in parallel with temporal shift (Fig. 4).

Raw VISSR data obtained by GMS are transmitted to the CDAS as a burst signal which is denoted as VISSR raw data A in Fig. 4. VISSR raw data B received at CDAS are demodulated, reformatted into the S-VISSR data and modulated by a VISSR data equipment, then the S-VISSR data C are transmitted to GMS. GMS relays the S-VISSR data D, which occupy the vacant time of GMS transmitter.

Finally, the relayed S-VISSR data are transmitted to the MDUS as the signal E. The data are received at the MDUS approximately 0.72 sec after the primary acquisition of raw VISSR data by GMS. As a result, at the end of VISSR observation, the MDUS turns out to receiving all S-VISSR data. Since the S-VISSR data are transmitted for every VISSR observation, the MDUS thus results in having the same amount of observed VISSR data as the DPC of Meteorological Satellite Center.

The main structure of the S-VISSR data may be summarized as follows :

a. VISSR image in the S-VISSR data format will be assigned to three sectors for infrared data where two sectors are reserved for future expansion and four sectors for visible data.

b. The data transmission rate of GMS will be fixed regardless to the spin rate variation of the satellite, so that fixed scheme may have advantage of easier acquisition of the S-VISSR signal at the MDUS.

c. Grid information on the latitude/longitude and cost line will be contained in the image data words. However, necessary parameters for mapping by users will be inserted into the documentation words, which are generated by DPC computer system. The S-VISSR data format is briefly described in Fig. 5.

3. Present and Future Schedule of VISSR observation and FAX Dissemination

The computer system operated at the DPC, Meteorological Satellite Center, will be replaced by a new computer system in March 1987. Furthermore, the new telecommunication ground facilities will be introduced in March 1988 and S-VISSR dissemination will begin at this time. The transition of the VISSR observation and dissemination schedule is briefly summarized in Table 1.

After introduction of the new system, FAX dissemination schedule will be changed according to three phases, I, II and III. After Phase II, all VISSR observation data will be transmitted in the form of S-VISSR on real time basis.

3-1 Present schedule

The VISSR observation has been currently performed on three hourly basis. Three images are additionally taken at around 00z and 12z each for cloud motion wind derivation.

3-2 Phase I

After the new computer system is introduced the three hourly basis will be still kept for full disk observation. Additionally hourly observation for the northern hemisphere will be performed, but sometimes it will be missing due to system maintenance.

3-3 Phase II

After the introduction of the new telecommunication ground facilities, the S-VISSR digital data disseminations for all observations will be started, still keeping analogue HR-FAX dissemination. During the Phase II period, the VISSR observation and FAX dissemination schedule will be the same as during the Phase I period. During the Phase II period, MDUS receiving facilities have to be replaced by stretched VISSR receiving ones.

3-4 Phase III

In Phase III, the analogue HR-FAX will no longer be disseminated through the satellite. Full disk VISSR observation for wind derivation around at 06Z and 18Z will start in the Phase III instead of half disk observation in the Phase II. The S-VISSR digital data dissemination will be performed for all observations.

PART VI - Validation and verification of satellite data and derived products used in operations, including performance statistics

PART VII- Other items (references, publications and the names of scientists in charge, etc.)

Publications

Inoue, T., 1987, A cloud type classification with NOAA-7 split window measurements., J. Geophys. Res. (in press)

Inoue, T., Instantaneous rain area delineation for convective case using split window data of AVHRR onboard NOAA-7. (Submitted to J. Meteor. Soc. Japan)

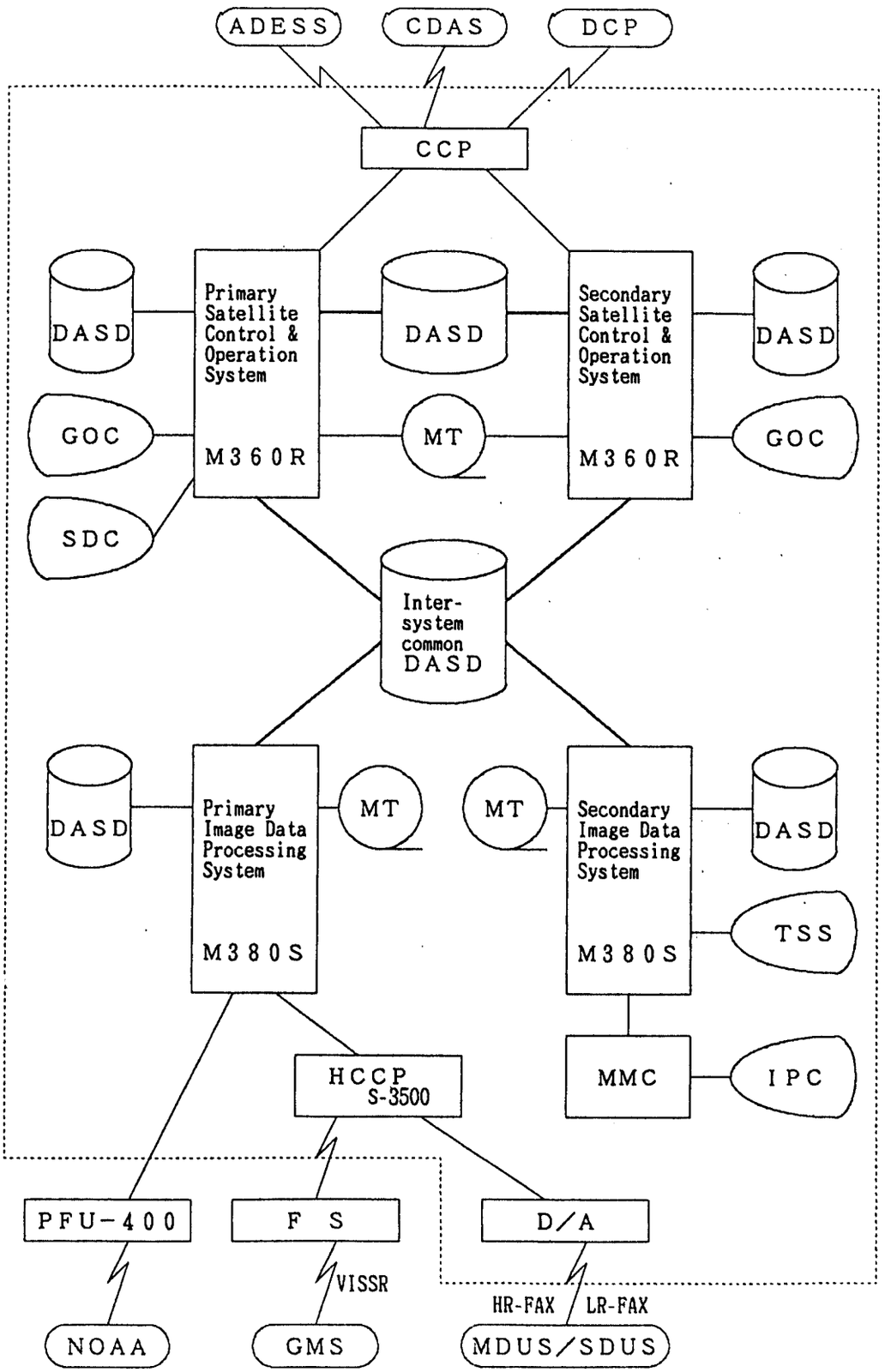


Fig. 1 Conceptual Scheme of the new computer system

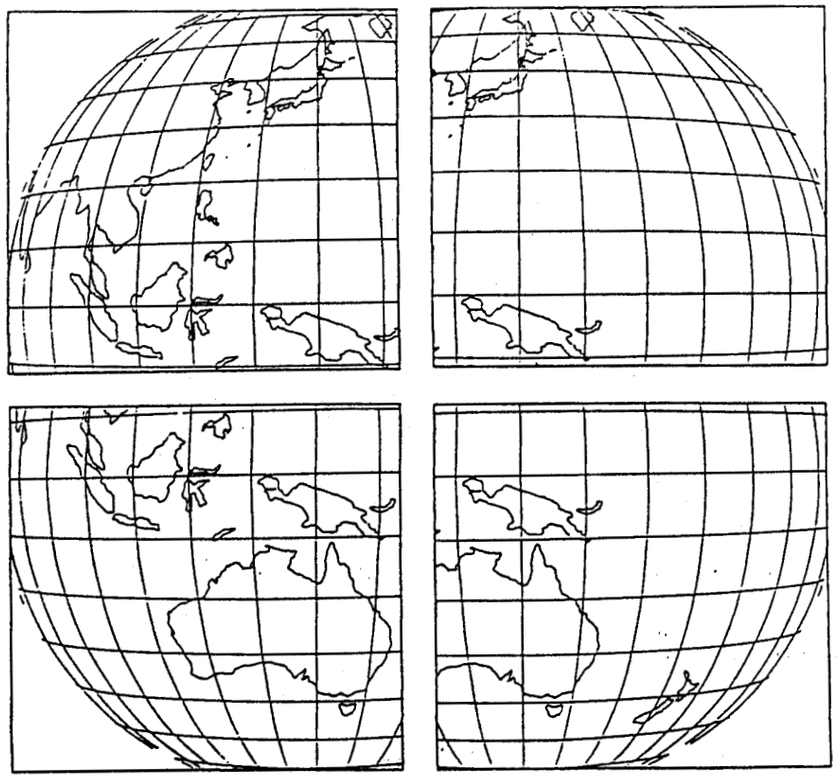


Fig. 2 Format of four-sectorized LR-FAX picture.

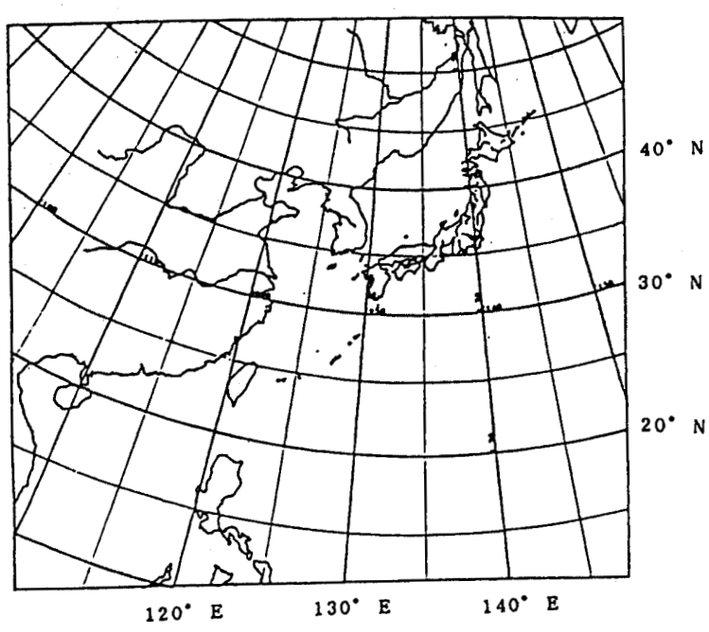
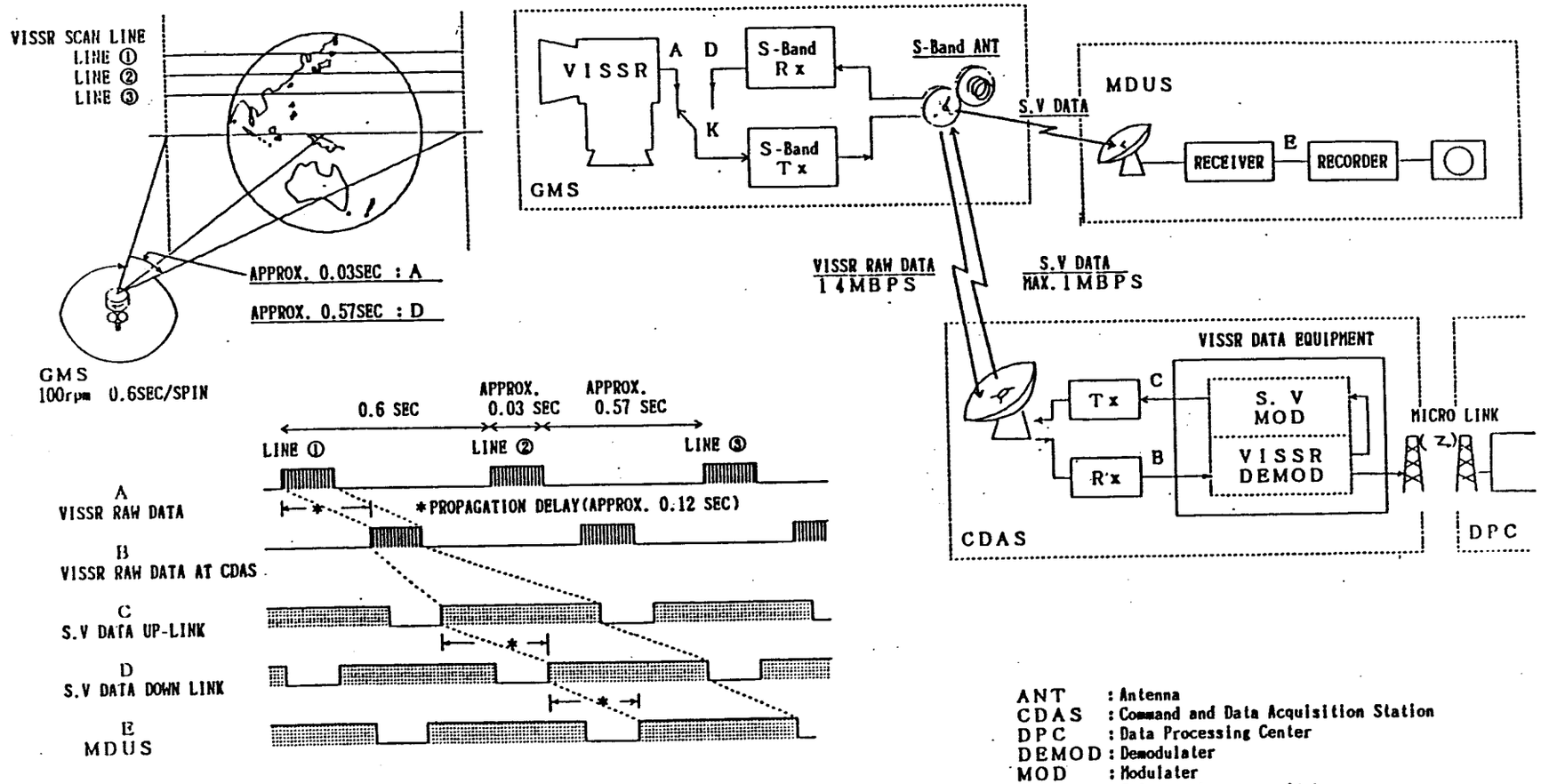


Fig. 3 Format of polar-stereographic pictures over the Far East area surrounding Japan.
Scale : 1/30-million



ANT : Antenna
CDAS : Command and Data Acquisition Station
DPC : Data Processing Center
DEMOD : Demodulater
MOD : Modulater
K : Spin synchronous switch
Rx : Receiver
Tx : Transmitter
S. V : Stretched VISSR
S/C : Spacecraft

Fig. 4 Time Chart of the Stretched VISSR Data.

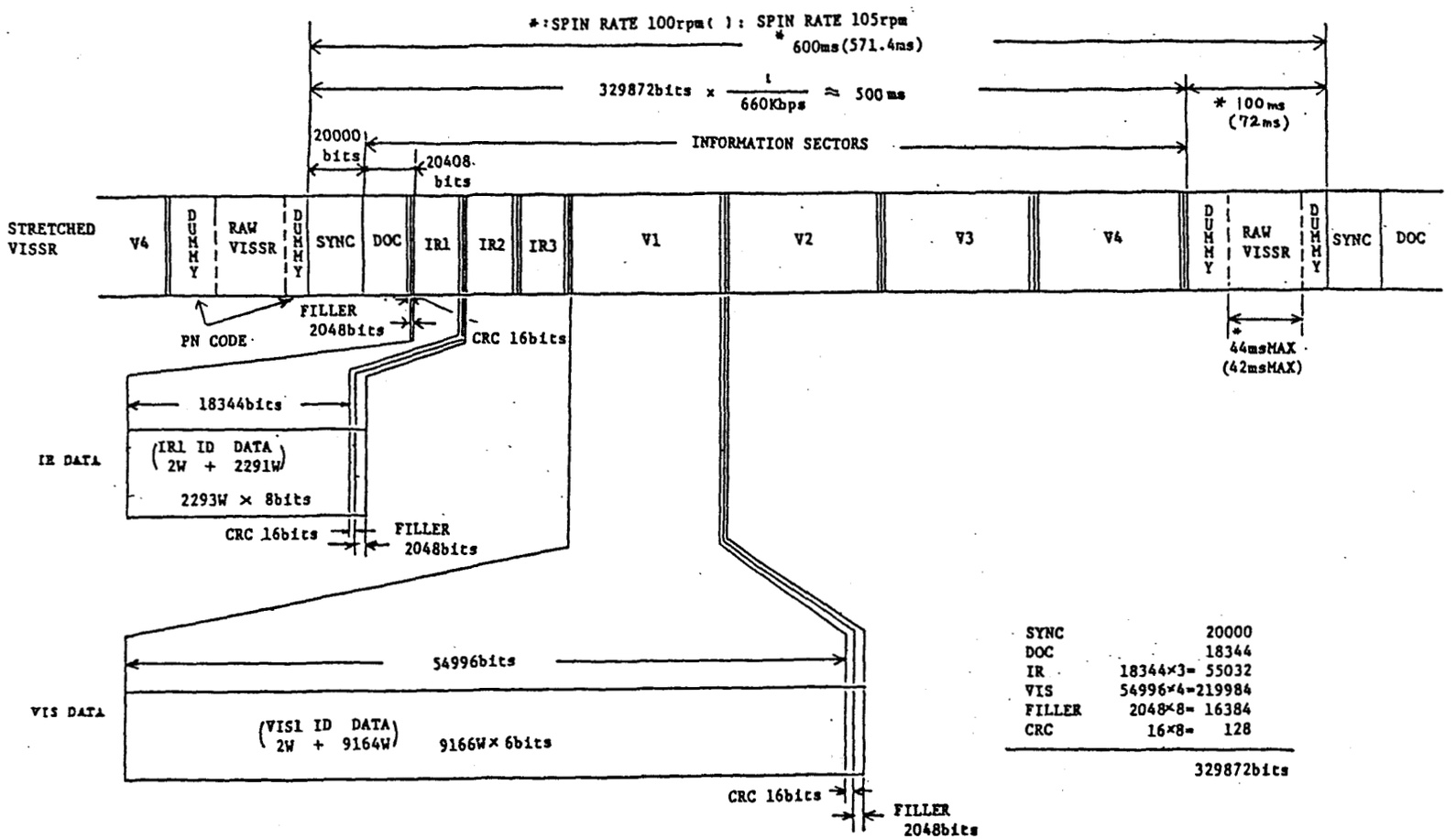


Fig. 5 Stretched VISSR Data Format.

Table 1 VISSR observation and dissemination schedule

Period	Current - Feb. 1987	Phase I March 1987 - Feb. 1988	Phase II (**) March - May 1988	Phase III (**) After May 1988
General		New DPC Computers	New ground facilities	
Observation				
Regular obs.	Full disk 8 times/day Full disk (three successive obs. for wind calculation) twice/day	Full disk 8 times/day Full disk (two successive obs. for wind calculation) twice/day Half disk (two successive obs. for wind calculation) twice/day	Same as Phase I	Full disk 8 times/day Full disk (two successive obs. for wind calculation) 4 times/day
Semi-regular obs.*	-	Hourly half disk (N.H.)		Hourly half disk(N.H.)
Special obs.	Special hourly obs. (N.H. or S.H.)	Special hourly obs. (S.H.)		Special hourly obs. (S.H.)
Stretched VISSR (S.VISSR)	None	None	S.VISSR dissemination for all observations including wind and special observations	
HR-FAX	Full disk (IR) 8 times/day (VIS) 3 times/day Mercator proj. (IR) 4 times/day	Full disk (IR) 8 times/day (VIS) 3 times/day Mercator proj. (IR) 4 times/day	Same as Phase I	Ceased
LR-FAX	7 sectors and H, I/J	4 sectors and H, I/J (Polar stereo-graphic projection)	Same as Phase I	Same as Phase I
Comment * Some times these obs. will be stopped due to system maintenance			** As for the date of the end of Phase II and the beginning of Phase III, JMA would like to ask for the opinion of the users.	

KENYA

PART I : SUMMARY

This report summarizes the applications of satellite technology to meteorology as an aid to weather forecasting. The forecasts issued from the National Meteorological Centre (NMC) are public, agricultural, aeronautical and marine weather forecasts. It also touches on the centres which utilize satellite photographs for surveying and mapping.

PART II : RESEARCH AND DEVELOPMENT

The following research projects are being undertaken with the additional application of satellite data:

1. Some aspects of the 1984 long rains season - aimed at identifying the synoptic features associated with the failure of 1984 long rains over Kenya.

   by Mr. P.G. Ambenje

2. Some characteristics of the ITCZ over Africa and neighbouring sea areas - whose objective is to develop methods of forecasting the seasonal performance of ITCZ at various locations and give early warnings.

   by K.N. Mutaku, J.K. Patnaik and J.R. Mukabana

3. Estimation of rainfall amounts from satellite imagery using an empirical method - it can be used to estimate rainfall where there are no direct measurements.

   by Mr. E.O. Bukachi

4. Analysis of Landsat - 4 Thematic Mapper data to facilitate classification of Kenya's climatic regions using Landsat imagery.

   by Miss J. Ahindukha

5. Influence of cyclone activities on the monsoon circulations over eastern Africa leading to determination of duration of the rainy seasons and amounts of seasonal rainfall.

   by Mr. P.M. Nthusi

PART III : TECHNIQUES DEVELOPMENT AND APPLICATION

Images Data

The National Meteorological Centre and the Institute for Meteorological Training and Research (IMTR) receive both APT(Automatic Picture Transmission) picture direct from the polar orbiting satellites and processed WEFAX pictures from METEOSAT. Four types of pictures namely, Infra Red (IR), Visual (VIS), Water Vapour (WP) and Cloud Top Height (CTH) are received and recorded on a HELL recorder (at IMTR) and the CIT/ALCATEL station APT/WEFAX - at the NMC. The NMC station is fitted with a PERICOLOR display unit which records real time images. Using this facility it has been possible to get colour displays, animations, filtered pictures and blow-ups.

Other Data

The NMC has for several years used SATOBS (Satellite Observations) data to augment data over Africa, Indian Ocean and Atlantic Ocean. These data have greatly aided both marine and aeronautical weather forecasting.

Technique Development

Through the daily weather conferences held at National Meteorological Centre (NMC) some techniques relating to use of satellite pictures have evolved. The pictures are particularly useful in aiding analysis of conventional data especially in detecting the position of the ITCZ and forecasting its future behaviour. Significant weather charts for aeronautical users are prepared with the aid of satellite pictures.

PART IV : OPERATIONAL SATELLITE DATA APPLICATION

Satellite images have aided in preparation of weather forecasts for the general public. Weather presentation on television has also been made much easier for public to understand, by using satellite pictures.

The specialised medium-range forecasts for the farming communi and the daily shipping and aeronautical forecasts have also benefitted from the use of the pictures.

The operations of Geosurvey International in Kenya have involved utilization of satellite pictures for mapping of areas under clear skies from the air.

PART V : FUTURE PLANS

Tropical Cyclones

In future, satellite imagery will be useful in estimating the intensity of Tropical Cyclones using the methods developed by Dvolak. It will therefore be easier to locate the centre of storms in the initial stages and forecast the direction of movement and the associated weather. They will continue to be utilised in research for a better understanding of the tropical synoptic systems.

Rainfall

So far estimation of rainfall from convective clouds has not been done using satellite photographs. By the end of the year 1987, after acquiring a Primary Data User Station (PDUS), there will be improvement in research towards estimation of rainfall using digital satellite data.

The station at the IMTR has been acquired with a video display unit for training purposes.

PART VI: VALIDATION AND VERIFICATION

No statistical procedures for verification of the product of satellite data are in use presently. The satellite information has however been a useful tool in qualitative assessment of forecasts where there are no reporting stations.

MALAYSIA

PART 1 SUMMARY OF MAJOR HIGH LIGHTS OF RESEARCH APPLICATION AND OPERATIONAL CHANGES

1.1 High Resolution Imageries (HR Fax) from the Japanese Geostationary Meteorological Satellite (GMS) and AVHRR Imageries from NOAA Satellite were received daily for operational use in the provision of meteorological services to aviation, shipping and the general public.

1.2 There were no major operational changes in 1986.

PART 2 MAJOR RESEARCH AND DEVELOPMENT IN THE APPLICATION OF SATELLITE DATA

2.1 Research on estimation of convective transport of mass and energy in monsoon disturbances based on enhanced satellite imageries is still in progress.

PART 3 TECHNIQUE DEVELOPMENT

NIL

PART 4 DESCRIPTION OF SYSTEM IN OPERATIONAL USE

4.1 A block diagram of the meteorological satellite ground reception system is shown in Figure 1.

4.2 The GMS HR and TIROS-N AVHRR signals are picked up by a 5m semi-fixed antenna and a 2.4m autotrack antenna respectively. After being discriminated/demodulated, they are recorded on a 9-track, 1600 bpi computer compatible tape.

4.3 The brain of the system is the Weather Image Processor (WIP) which is made up of a digital image processor channel and a microprocessor which controls the parameters used by the channel to process imagery. Different level of brightness associated with various cloud features can be performed using radiometric enhancement and applying different Look-Up Tables (LUT).

4.4 The colour video display is controlled by a video display processor (VDP). The WIP permits 16 pictures to be shown in an animated sequence on a video monitor.

4.5 Both IR and Visible cloud imageries can be enhanced at magnification of scales 1, 2, 4 and 8 respectively in photo-fax copies. Pictures produced by the facsimile recorder are in 16 grey scales.

PART 5 PLANS FOR FUTURE OPERATIONAL SYSTEMS

5.1 Plans are being made to upgrade our present GMS/NOAA Satellites reception system in response to the planned digital GMS to be launched by JAPAN in 1988.

5.2 Plan is also being made to integrate information received from the satellite and radar systems and the convectional rainfall ground stations. Although this is merely in a conceptual stage, several proposals regarding the above project have been received from several private companies.

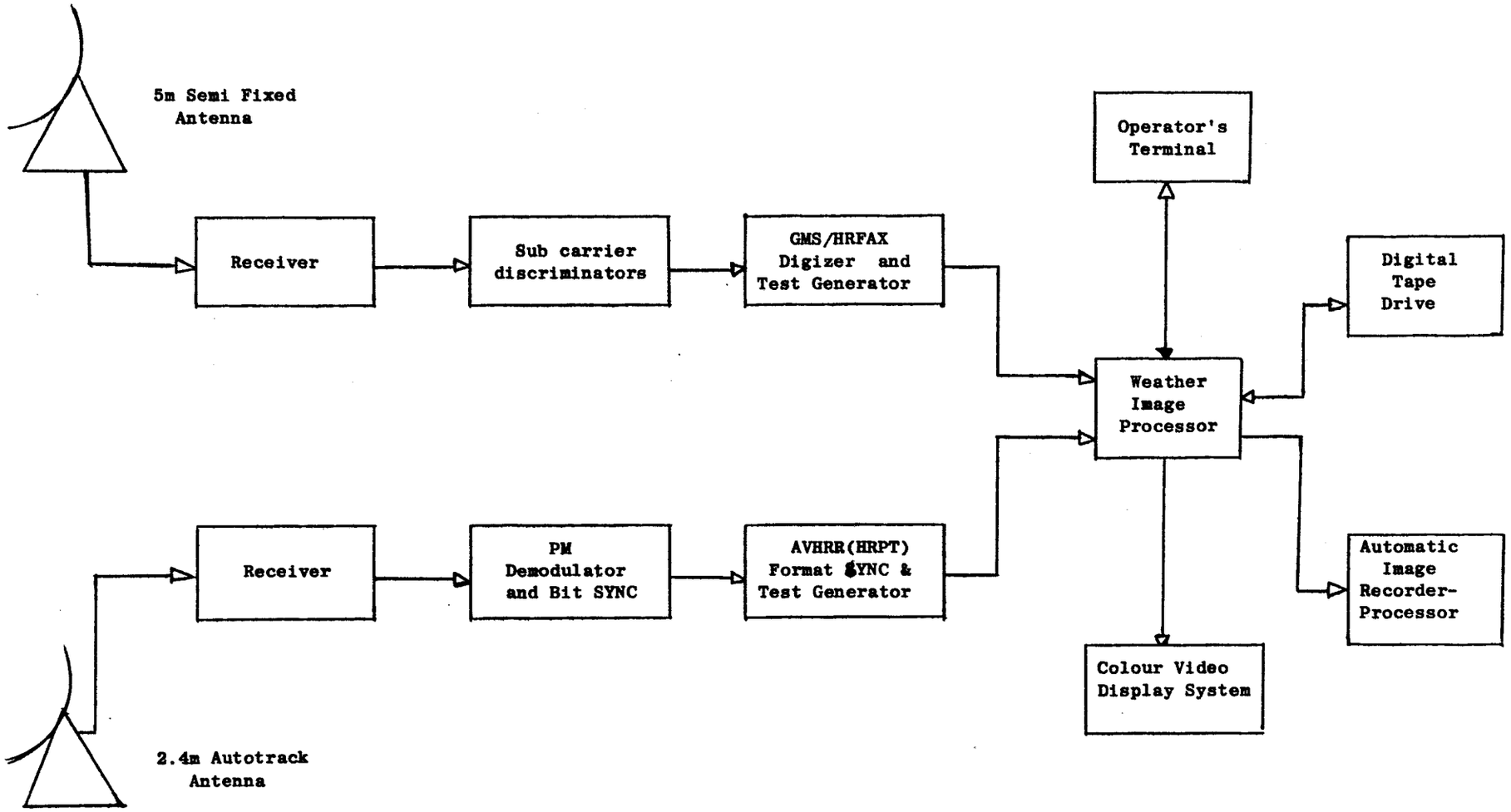


Figure 1 : The Meteorological Satellite Reception System Used By Malaysian Meteorological Service, Malaysia.

NEW ZEALAND

Meteorological Service, Wellington

1 MAJOR HIGHLIGHTS

A new computer has been installed. On a research basis, a pattern recognition based Maximum a Posteriori simultaneous physical retrieval scheme has been developed and tested.

2 RESEARCH AND DEVELOPMENT

2.1 Profile retrievals

Research on the Typical Shape Function, Maximum a posteriori Simultaneous (TMS) physical retrieval scheme is continuing. A full validation analysis of the retrieval algorithms has been carried out using synthetic TOVS data. In addition, the TMS estimator has been applied to NOAA 7 data (M.J. Uddstrom).

3 TECHNIQUES DEVELOPMENT

No new developments.

4 OPERATIONAL SYSTEM

No major changes.

5 FUTURE OPERATIONAL SYSTEMS

A computer upgrade (to a VAX 8650) occured toward the end of the year. As a consequence, the ITPP-3 retrieval software will be installed on this computer in early 1987, together with image processing software. The TMS physical retrieval estimator should be available for operational testing toward the end of 1987 (M.J. Uddstrom, J. Kidson).

Meteorologists not located in the National Weather Forecasting Centre (NWFC) ,Wellington, will have improved access to satellite products, upon installation of Branch Office computers at Auckland and Christchurch.

High resolution colour graphics terminals for NWFC and medium resolution terminals for the two branch offices will be purchased during the year for the display of imagery, observations and NWP products.

6 VALIDATION OF SATELLITE DATA

An experiment to test the TMS estimator on a global sample of TOVS radiances supplied by Dr L. McMillin of NOAA/NESDIS is planned (M.J. Uddstrom).

A field experiment to obtain soil moisture, pasture growth and conventional meteorological ground truth measurements against which to validate satellite NVI measurements is continuing (M.J. Salinger, B.F. Taylor).

7 PUBLICATIONS

Taylor, B.F., P.W. Dini and J.W. Kidson, Calibration of Normalised Vegetation Index against pasture growth. In *Proceedings of an International Satellite Land-Surface Climatology Project* (ISLSCP) *Conference*, 2-6 Dec., 1985, Rome, Italy, European Space Agency, ESA SP-248, 293-297.

Uddstrom, M.J., Synthetic and real data applications of the Typical Shape Function Simultaneous physical retrieval algorithm. In *The Technical Proceedings of the Third International TOVS Study Conference*, Madison, Wisconsin, USA, 13-19 Aug., 1986, CIMSS Report, SSEC, Univ. Wisconsin, Nov. 1986, 283-311.

Uddstrom, M.J., Atmospheric profile retrievals from an algorithm utilising pattern recognition and physical simultaneous retrieval estimators. In *Extended Abstracts of the Second International Conference on Southern Hemisphere Meteorology*, Wellington, New Zealand, 1-5 Dec., 1986, American MeteorologicalSociety, 248-251.

Uddstrom, M.J., Retrieval of atmospheric profiles from satellite radiance data by Typical Shape Function Maximum a Posteriori Simultaneous retrieval estimators. 1986, Submitted to *J. Clim. Appl. Meteor.*

NORWAY

PART 1 Summary

HRPT and PDUS receiving stations are operated at the headquarters of the Norwegian Meteorological Institute. Satellite data are used in the routine forecasting service and for monitoring of the Arctic ice border. Satellite images are also used for mapping of the snow cover.

To ensure timely reception of observations from drifting buoys and other automatic stations with Argos Platform Transmitter Terminals (PTT's), a local user Terminal (LUT) has been established as part of the HRPT readout station. The LUT has collection location and dissemination capabilities built in.

PART II and III

(a) Sea surface temperatures

AVHRR thermal channels are used to calculate sea surface temperatures. These data are combined with measurements from ships and buoys. Our sea surface temperature analyses cover the ocean areas between approximately 50°N to 82°N and 30°W to 60°E.

(b) Cloud top temperature

Cloud top temperatures are also calculated from the AVHRR thermal channels, and are being used by the forecasters in their routine work. From successive data sets it is possible to extract changes in cloud top temperature distribution and thus follow movement and development of cloud systems. Also live cycles of connective cells are followed.

The cloud top temperature calculations combined with multispectral AVHRR information are used to study the structure of intense so-called polar lows. Much effort is put into the work of improving the forecastig methods of these small storm centers.

Combined with information from radiosonde ascents the height of clouds are estimated by this method.

(c) Vertical temperature profiles

To a certain extent calculation of vertical temperature profiles have been made using the four channel MSU instrument.

Until now a simple statistical calculation method has been used.

(d) Neph-analyses

On a daily routine basis Neph-analyses covering the European region are carried out by use of multispectral AVHRR information.

(e) Sea ice mapping

Mapping of the sea ice in the arctic region between Greenland and Novaja Zemlja has been carried out at the Norwegian Meteorological Institute since 1970. This service is totally dependent on satellite images.

In the summer season mostly the visual channels of AVHRR are used, in winter time in darkness only the infrared channels give adequate information.

Until now we have not implemented any form of multispectral use of the AVHRR for ice mapping, but only rectified images with grey scales.

The two main problems are:

(a) To distinguish between ice and clouds
(b) Registration, i.e. geographical positioning of the ice.

For (a) it is necessary to have many images covering the same area. Thus fast moving clouds can be identified and accordingly separated from the ice.

For (b) it is essential to see landmarks in the images to be able to correct the computed geographical grid. For both operations skilled operators are needed to obtain useful results.

PART IV

(a) Data collection

The LUT operates in the S-band with a real-time readout in the HRPT-format. The station is operated on a 24 hour basis. The DCP data in TIP-format are separated from the AVHRR-data and decoded. All data received within the area of coverage of the antenna are decoded. Positioning is carried out for platforms as necessary by using the Doppler-data received. The accuracy of the positioning depends on many factors, but typical operational values are about 1 km for drifting platforms.

After calibration, the data are encoded into different formats for dissemination on different telecommunication networks.

(b) Satellite images

Satellite images are made operationally available with Meteosat PDUS and NOOA-HRPT.

For NORWAY the NOAA near polar orbiters are the most important satellites. With a twin satellite system it is possible to receive more than 20 orbits per day at our station in Oslo. Most of the orbits cover some parts of our area of interest.

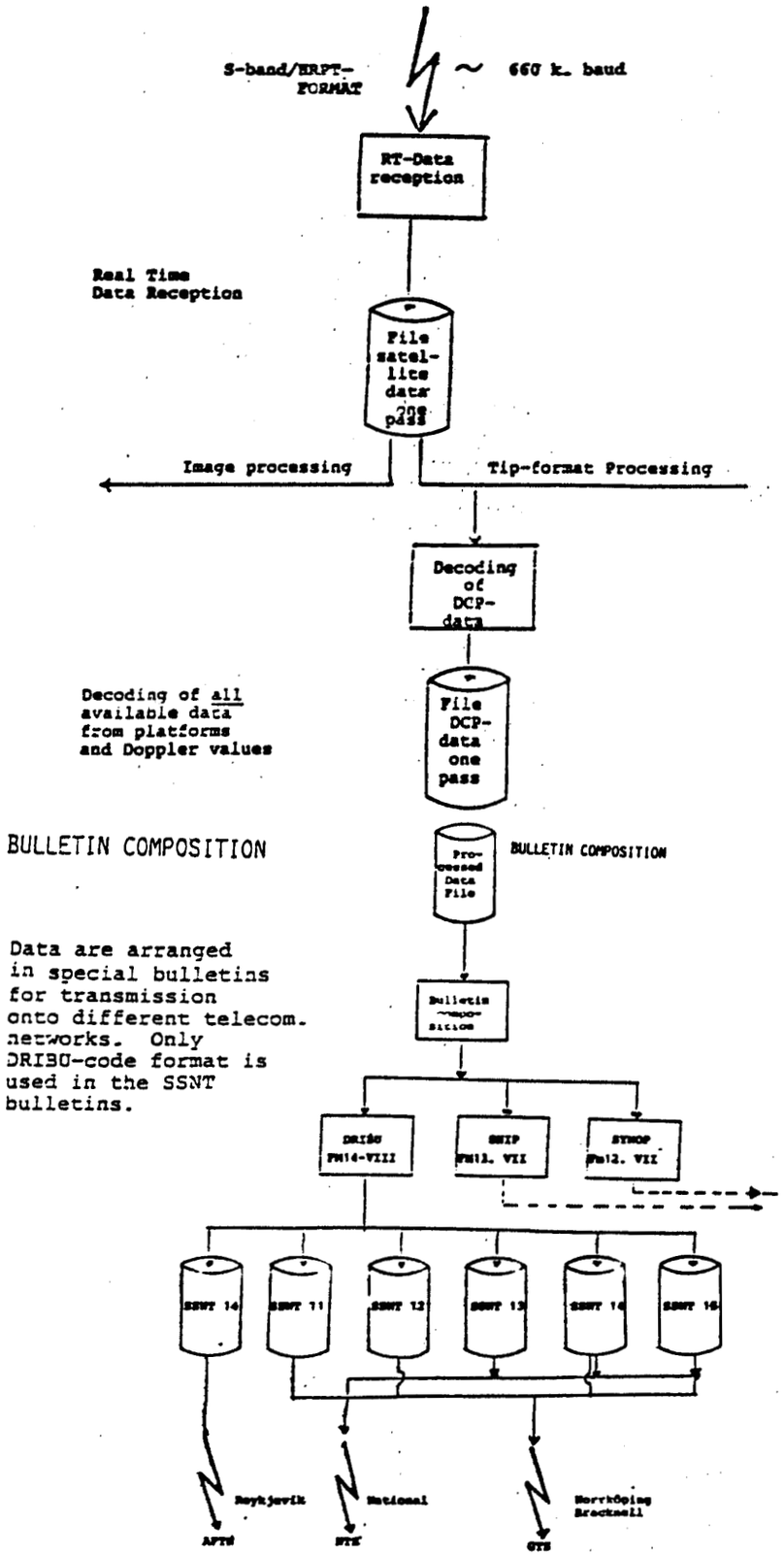
Meteosat gives very useful information S of approx. 67^0N. The Meteosat information is calculated by a PDP 11/73 computer.

The HRPT information is received by a Datron antenna, calculated by ND-100 computer, and presented on a Muirhead K 300 Mufax, Electronstatic plotter or line printer.

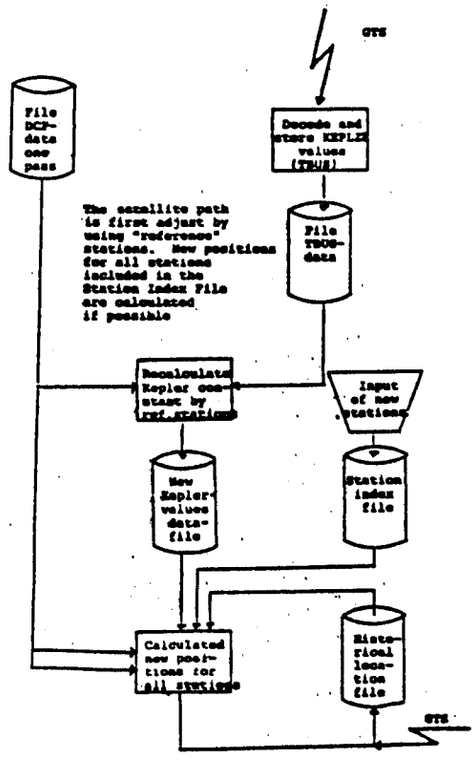
The data are corrected for the earth's curvature, calibrated, and converted to a near mercator map projection. Pixels are geographically located by using advanced orbit calculations, and every 5th latitude and 10th longitude circles are shown on the image. Images used in the operational routine are presented in a 4 km resolution.

Basic image handling methods are used to improve information. The methods are standardized, chosen to give optimal results for each season. Interactive image handling software are developed for detailed studies of weather or sea surface phenomena.

SATELLITE DATA ACQUISITION AND DECODING OF DCP-DATA



PLATFORM LOCATION



PART V

It is planned to increase efforts on developing methods of local implementation of TOVS data.

Furthermore, extended use of multispectral AVHRR information is foreseen.

Finally, the possibilities of using low bit rate data (wind and waves) from the ERS-1 satellite will be looked into.

PART VII

Contact: Jens Sunde

PAKISTAN

PART - I
PART - II
PART - III

Pakistan Meteorological Department has as yet not been able to make full use of Satellite data and its applications.

PART - IV A brief description of the system for satellite applications in operational use in 1986

Pakistan Meteorological Department operates a network of three APT Ground receiving stations located at Karachi, Lahore and Peshawar. However, the APT Ground receiving station at Peshawar is not operational at present and needs replacement. The APT Ground receiving stations located at Weather Central and Main Analysis Centre at Karachi and the Flood Forecasting and Warning Centre at Lahore are receiving cloud pictures from NOAA series polar orbiting meteorological satellites. These APT Ground receiving stations have presently limited capability of acquiring cloud pictures only. Further applications of remote sensing of spectral radiation for measurements of meteorological and operational hydrological parameters are not possible. Cloud pictures received are being utilized by Pakistan Meteoroloical Department for operational weather forecasting by its Meteorological Offices at Karachi and Lahore International Airports, and also for the issue of flood warnings by the Flood Forecasting and Warning Centre at Lahore during the monsoon period and for identifying and estimating movement of cyclones and frontal system in the area.

PART - V Plans for future operational systems for satellite applications to meteorology and operational hydrology

Pakistan Meteorological Department intends to strengthen the network of APT Ground receiving stations. Non-availability of direct read-out from Geostationary meteorological satellite in the area is, however, a major handicap.

PART-VI No system for validation and verification of satellite data is presently in operation in Pakistan Meteorological Department.

PART-VII Names of scientists-in-charge

(a) Director,
Flood Forecasting and Warning Centre,
46-Gulberg Road, Lahore - 3, PAKISTAN.

(b) Director,
Forecasting and Climatology,
Pakistan Meteorological Department,
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University Road,
Karachi - 32. PAKISTAN.

PHILIPPINES

This progress report summarizes the activities on the applications of satellite technology to meteorology and operational hydrology of the National Weather Office (NWO) and the National Flood Forecasting Office (NFFO), PAGASA respectively, during 1986.

PART I: A BRIEF SUMMARY OF THE MAJOR HIGHLIGHTS OF RESEARCH APPLICATIONS AND OPERATIONAL CHANGES

1.1 Scheduled transmission of High Resolution Facsimile (HR-FAX) imageries, from the Japanese Geostationary Meteorological Satellite (GMS) were received during most of the first quarter (of 1986) and May except during April and June (2nd quarter) since it became inoperational on June 13, 1986 up to the end of 1986. The National Weather Office of PAGASA had to rely solely on the Japan Meteorological Agency (JMA) Facsimile transmissions which consists of Meteorological Satellite Picture (GMS) and the NEPH-ANAL (GMS) in their operational weather forecasting work.

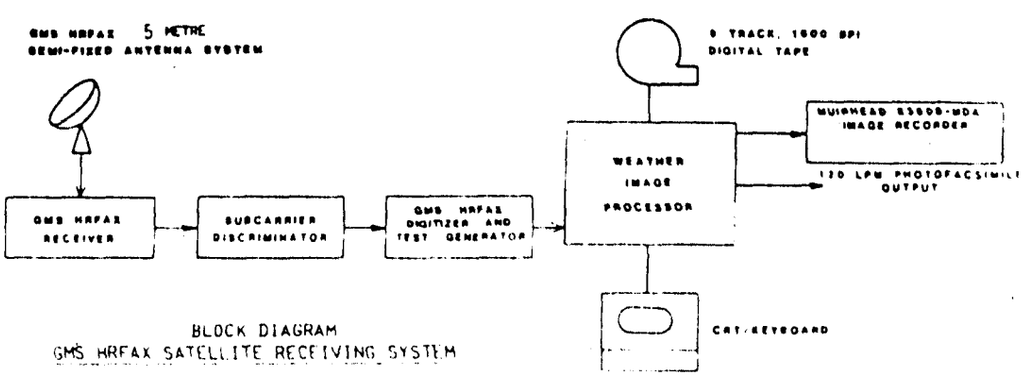
1.2 No operational changes in 1986.

PART II: A DESCRIPTION OF THE MAJOR RESEARCH AND DEVELOPMENT IN THE APPLICATIONS OF SATELLITE DATA, DERIVED PRODUCTS AND SERVICES

Not Applicable

PART III: A DESCRIPTION OF TECHNIQUES DEVELOPMENT AND APPLICATIONS OF SATELLITE DATA, DERIVED PRODUCTS AND SERVICES

During the 1986 typhoon season, the National Weather Office (NWO) Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) was the main user of both the Enhanced Infra-red (EIR) and the High Resolution Facsimile (HR-FAX) imageries received from the Japanese GMS-3. The use of the above pictures in the detection/tracking and in the interpretation of the intensity of tropical cyclones can not be overemphasized. Severe weather disturbances generally associated with organized convective activity other than tropical cyclones like heavy rain, thunderstorm, etc. are not that difficult to infer from HRFAX cloud imageries received at three hourly intervals. As in previous years, tropical disturbances which traversed the Philippine Area of Responsibility (PAR) and developed into tropical cyclones were observed to have emanated from cloud systems in the Inter-Tropical Convergence Zone or near it.



BLOCK DIAGRAM
GMS HRFAX SATELLITE RECEIVING SYSTEM

PART IV: A BRIEF DESCRIPTION OF THE SYSTEM FOR SATELLITE APPLICATIONS IN OPERATIONAL USE IN 1986

The basic GMS-HRFAX Ground Receiving System consists of two basic subsystems:

1) GMS Input Subsystem and
2) Weather Image Processing Subsystem

A block diagram of the GMS-HRFAX system is shown in the preceeding page:

PART V: PLANS FOR FUTURE OPERATIONS SYSTEMS FOR SATELLITE APPLICATIONS TO METEOROLOGY AND OPERATIONAL HYDROLOGY

Aside from plans of PAGASA to upgrade the present basic system in order to have the capability to receive stretched VISSR image by 1988, there are plans to install NESDUS 60 and NESDUS 70 Ground Receivers (from External Assistance) which are capable of receiving low resolution satellite pictures from Japan's GMS-3 and from polar orbiters.

POLAND

Part I

In 1986 in Polish Hydrometeorological Service three receiving stations worked - in Cracow, in Warsaw and in Gdynia.

The biggest development was achieved in 1986 in the Cracow station. It became furnished with the devices for receiving, recording and processing the AVHRR data from TIROS N/NOAA satellites and with the computer system connected with monitors for WEFAX METEOSAT pictures displaying.

The new equipment, based on IBM-PC-AT computer, for temperature and water vapour profiles estimation using TIP data as well as the computer programs for this purpose, were installed.

The everyday APT pictures from NOAA and METEOR satellites and WEFAX transmission from METEOSAT receiving was continued since the last years. These pictures were used in everyday work in weather offices in Cracow, Warsaw and Gdynia. For other weather offices working in Poland the charts containing the satellite informations were prepared and transmitted by cable from Cracow.

Part II

The research works were concentrated on the estimation of temperature profiles and moisture profiles of the atmosphere from TOVS data as well as total ozone content and ozone mixing ratio profile, the cloud tops as well as sea surface temperatures AVHRR channel 3, 4 and 5 data. The cloud layer thickness estimation using the AVHRR channel 1 pictures was under consideration either.

The set of temperature profiles estimated from TIP data were compared with the aerological ones. This analyse of errors indicates that exactness of the method of temperature profile retrieval is comparable with the methods working in the other meteorological centers in the world. The further research works concerning an improvement of exactness of this method are planned.

The cloud tops temperatures and cloud layers thickness estimations were accomplished, while using the regression methos for picture calibration, the enhancement of the pictures containing the cloud layer thickness or cloud top temperatures in the required limits could be achieved using the new device for processing system. In 1986the primary results were obtained and the further research works for achieving the sufficient exactness of cloud top temperatures and cloud thickness estimation are needed.

Since 1985-86 the first experiments to utilize SATEM-data for numerical analysis of humidity for the operational forecast model have been taken up. For the North Atlantic Ocean, the fields of dew-point deficit are obtained by two methods, for the levels 850, 700 and 500 hPa. The first, dynamic method based on the hydro-termodynamic equations and the second, statistical method, which takes into account SATEM-cloud-data and other kinds of information in regression equations. The results do not qualify any of these methods for including them into the operational forecast system. But they show possibile to utilize SATEM humidity-data in the methodical mesoscale forecast system.

On the base of the images obtained from the satellite METEOSAT-2 the works are carried out on macroscale evolution of the cloud system classification of types and development of cyclogenesis over the Europe continent.

Part III

In 1986 the new devices for receiving and processing of AVHRR and TIP data were attached to the set of satellite receiving station.

The receiving, recording and processing AVHRR data system designed by Wroclaw Technical University consists of s-band receiver connected with magnetic tape PT 305 and FOTOFAX MUIRHEAD M300RJ records through the Z280 processor. Using this devices it is possible to record AVHRR pictures in two channels with the original resolution or in four channels with the resolution twice less than orginal. It is possible to enlarge any part of the picture 2, 4 and 8 times.

The user can enhance any part of the picture by introducing any look-up-table that he wants. The look-up-table be defined by values in up to fifteen points.

The computer system for WEFAX METEOSAT pictures recording on tv screens consists of two screens. It is possible to enlarge a part of a picture up to 4 times. It is used in this way, that on one screen the actual picture and on the other the picture received 1/2 hour earlier are seen.

Part IV

In 1986 the APT TIROS NOAA METEOR and WEFAX METEOSAT pictures were applied in operational use. They were used for synoptic analysis and forecasts as an additional information. They were also verified in an orginal manner and described in an orginal code for introducing them into the data basis for quantitative precipitation forecasts.

Satellite pictures were used this way in the weather offices in which the satellite receiving stations are operating /Cracow, Warsaw, Gdynia/. For the other Polish Weather Offices the charts were plotted and transmitted by cable from Cracow. As the fascimile satellite pictures from Offenbach and Bratislava are applied. They are received by radio. The satellite pictures and the films on cloud movements are used in everyday tv forecasts.

Part V

In the nearest future the use of AVHRR pictures enhanced and processed using the devices constructed in 1986 with attached IBM-PC-AT computer is planned. The cloud tops temperatures and the cloud layer thickness processed from AVHRR images should be used in routine work of the weather office in Cracow and Warsaw, the coloured tv screen should be used for processing the APT pictures in the false colour mode.

The system of receiving, recording and processing of WEFAX METEOSAT pictures will be applied. This system is designed by Wroclaw Technical University and is based on the operation of IBM-PC-AT computer. That will enable the recording and processing of WEFAX data, this includes weather maps, and to present them in the selection colours and the animation of following images with the adapted speed. The arrangements to punt into opetation the receiving station for HRPT data from METEOSAT-2 are carried out.

The data in addition to radiolocative and synoptic data will enable development of nowcasting forecast.

Part VI

1. Barański L., -"Satellite Data Receiving and Processing Techniques in the Institute of Meteorology and Water Management", Proceedings of the Conference "The Use of Satellites in Sea Transport", , Gdynia, May 1985, published in 1986

2. Barański L.,Struzik P., -"The Equipment for Receiving and Processing of TOVS Data Transmitted at frequency 137 MHz ", Proceedings of the Conference "The Use of Satellites in Sea Transport", Gdynia, May 1985, published in 1986

3. Bunsch-Makarewicz Z., - " The Possibility of Physical Interpretation of Clouds' Satellite Picture Described by Statistical Parameters of Brigthness Field", Proceedings of the IV-th Symposium of Meteorologists "Problems of Meteorology for Aviation Protection", Sobieszewo, Septemler, 1985, published in 1986.

4. Bunsch-Makarewicz Z., -"The estimation of Clouds' Tops Temperature and Clouds' Thickness Using Satellite Data Processor "Proceedings of the V-th Symposium of Meteorologists "Meteorology and Transport", Duszniki, November 1986.

5. Dyras I., - "The Illustration of Visually Distinguishable Features of Cloud Field by Statistical Parameters of Satellite Picture ", Proceedings of the IV-the Symposium of Meteorologists "Problems of Meteorology for Aviation Protection", Sobieszewo, September, 1985, published in 1986

6. Dyras I., - "The Use of AVHRR Digital Pictures Analysis for the State of Physical Fields Description", Proceedings of the Conference " The Use of Satellites in Sea Service", Gdynia, May 1985, published in 1986

7. Dyras I., - "The Systems of Recording and Processing of High Resolution Satellite Pictures", Communication on the International Symposium "Digital Information Processing in Radiolocation Meteorology", Jabłonna, May 1986

8. Dyras I., - "AVHRR Pictures Recording and Processing Using Satellite Data Processor " Proceedings of the V-th Symposium of Meteorologists "Meteorology and Transport", Duszniki, November 1986.

9. Stano S., - "The Equipment for APT and WEFAX Satellite Pictures Recording on TV Screen", Proceedings of the Conference Proceedings of the Conference "The Use of Satellites in Sea Service", Gdynia, May, 1985, published in 1986

10. Rymarz Cz., - "Satellite Meteorology Serving Navigation", Proceedings of the Conference "The Use of Satellites in Sea Service", Gdynia, May 1985, published in 1986.

PART VII

The list of specialists :

Barański Lesław - Management for receiving and computer processing of satellit e data for solar radiation budget determination

Application of TOVS satellite data for temperature, moisture and ozone determination

Rożemski Krzysztof- Mathematical and physical methods for processing and interpreting of TOVS and HRPT satellite informations for meteorology and atmospheric science

Stano Sławomir - Projecting of electronic systems for receiving and processing of analogue and digital satellite informations

Biczewski Aleksander - Constructing of electronic devices for receiving and registrating of satellite analogue data

Struzik Piotr - Projecting of informatic systems for processing of digital satellite transmission /hardware and software/

Bunsch-Makarewicz Zofia - Physical interpretation of satellite pictures

Dyras Izabela - The objective methods of digital satellite pictures analysis

Address: IMGW
30-215 Kraków
ul. Borowego 14

Kaczmarski Jan - Synoptic interpretation of satellite data

Klejnowski Ryszard- Application of satellite data for weather forecasts developed for aircraft

Rymarz Czesław - Evolution of macroscale cloudiness systems

Address:
IMGW
01-673 Warszawa

Barański Włodzimierz - Programming of receipt and processing of satellite data

Wojtaszek Ryszard - Construction of satellite receiving system

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Wrocław
Wybrzeże Wyspiańskiego 27
Poland

REPUBLIC OF KOREA

Korea Meteorological service

Part I - Summary

In 1986, there were no significant operational changes. There were temporary losses of data due to failure of system in GMS and NOAA satellites. The most serious problem for Korean operations was the interruption to GMS data during typhoons. On the research side, progress was made with the system for wide application processing of AVHRR from HRPT in Seoul.

Part II - Research and Development

Test software has been developed to process AVHRR imagery to obtain sea surface temperatures over areas near Korea. The scheme gives objective recognition of imagery characteristics and has important application in ocean research. Studies continued on ways to improve AVHRR processing. A sea surface temperature analysis scheme to constrain profiles was developed. Methods for improved sea surface temperatures were also developed.

Part III - Techniques Development and Applications

The main work continued to be directed towards improved enhancement algorithms for NOAA imagery. A system was developed for the analysis of sectorized digital imagery values from the pdp-11/60 computer to a colour display. A principal application of this system has been utilized to the analysis of sea surface temperatures in Korea. Development work continued on AVHRR CH-4 to derive sea surface temperatures over areas near Korea and to automate the storage and retrieval of full resolution NOAA imagery.

Part IV - Description of Operational System in 1986

(a) Imagery Data
1. HRFAX: Full-disk pictures;
Enhanced partial-disc pictures;
Enhanced pictures.
2. LRFAX: Eight sectorized pictures.
3. HRPT: VIS, IR pictures.

(b) TOVS
TOVS data are acquired directly by reception and stored on magnetic tape.

(c) Derived products
1. Nephanalysis chart (manually drawn) (2 times/day);
2. Cloud distribution chart (LP hard copy) (1 time/day);
3. Sea surface temperature chart (manually drawn).

Part V - Plans for Future Operational Systems

We have the plan to upgrade for satellite data application. Replacing new satellite receiving system is now underway according to schedule of Japanese GMS broadcasting methods from the present HRFAX to the stretched VISSR in 1988.

Part VI - Verification

As a project for AVHRR imagery study, test patterns of sea surface temperature over areas near Korea were verified against AVHRR data and observed data.

Part VII - Other items

Jong Hon Bong: Director-General, Meteorology Research Institute.
Hak Soo Yoon: Director, Satellite Meteorology Laboratory.

ROMANIA

Part I SUMMARY OF MAJOR HIGHLIGHTS OF RESEARCH APPLICATIONS AND OPERATIONAL CHANGES

The main concerns are directed towards:

- the automation of satellite data operational processing;
- the computation of some meteorological parameters using satellite information;
- satellite information operational involving in the qualitative and quantitative schemes for weather forecast and analysis.

Part II RESEARCH AND DEVELOPMENT

1. The operational processing programmes have been worked out and are about to be implemented as far as they concern:
   - geometrical transformations of the satellite information;
   - automated superposition of the objective analysis of a scalar field of interest;
   - illumination correction of the data in the visible spectrum;
   - superposition of the geographical canvas or the contours of interest on the images supplied by satellites.

2. The algorithms and programmes are being worked out on the:
   - automated analysis of the cloud field;
   - determination of the sea surface temperature;
   - computation of the cloud top height;
   - determination of the vertical temperature profiles;
   - determination of the wind vectors;
   - the use of satellite information in the mesoscale analysis of the atmospheric state.

Part III DERIVED PRODUCTS

At the present stage the following are supplied operationally:

- nephanalysis, according to the data supplied by the polar orbital satellites;
- frontal cloud system kinematics;
- METEOSAT sequences on demand;

Part IV A DESCRIPTION OF THE SYSTEM FOR SATELLITE APPLICATIONS IN USE IN 1986

Satellite information are approached by means of:

- an APT station working with the polar orbital satellites;
- a PDUS station working with the geostationary satellite METEOSAT;
- a system for data visualization through photographic facsimile and TV display;
- an I-1o2 F processing system in larger configuration.

Part V PLANS FOR FUTURE OPERATIONAL SYSTEM

- Installation of a digital data reception system supplied by polar-orbital satellites;
- Doubling the computation and processing system;
- Introduction of video-recorder systems for data storage.

Part VI VERIFICATION OF OPERATIONAL SATELLITE DATA

Satellite data are compared and analysed visually as against the available meteorological data. In order to determine the sea-surface temperature the data supplied by satellites are compared with the measurements in situ.

Part VII CONTACTS

Marinel Ioana
Institute of Meteorology and Hydrology,Bucharest for:
- primary processing, satellite image corrections;
- determination of sea surface temperature;
- automated analysis of the cloud field;
- cloud field kinematics;
- precipitation determinations according to satellite data.

Ioan Milos
Institute of Meteorology and Hydrology,Bucharest for:
- objective analysis of the scalar field;
- wind vector computation;
- determination of the vertical temperature profiles.

Toma Runcanu
Institute of Meteorology and Hydrology,Bucharest for:
- the use of satellite information in analog procedure for meteorological analysis and forecasting;
- cloud field climatology;
- mesoscale structures.

SINGAPORE

Part I SUMMARY OF THE MAJOR HIGHLIGHTS OF RESEARCH, APPLICATIONS AND OPERATIONAL CHANGES

There were no significant operational changes in 1986. For operational needs, HRFAX and selected LRFAX imageries from the Japanese geostationary meteorological satellite (GMS) and AVHRR data from the NOAA satellites are received daily and used in the provision of meteorological services to aviation, shipping and the general public. GMS data are also transferred routinely from the Satellite Reception System to the main computer system for archiving and and further processing. False colour outputs of GMS imageries are also available on graphics terminals and PCs.

Part II MAJOR RESEARCH AND DEVELOPMENT

Nil.

Part III TECHNIQUES AND APPLICATIONS OF SATELLITE DATA, DERIVED PRODUCTS AND SERVICES

Satellite imageries are used operationally for monitoring the development of weather systems and storms, in the provision of warnings of adverse meteorological conditions to aviation, shipping and the general public, and also in weather chart analysis. The high resolution GMS data are archived routinely in a lower resolution form (640 X 200 pixels) to cater to present operational requirements and for future research purposes.

Part IV DESCRIPTION OF OPERATIONAL SYSTEM

The Satellite Reception System in Singapore receives full disk high resolution imagery and low resolution sectors from GMS transmission every three hours. High resolution AVHRR data from the NOAA satellites are also received and used to complement the GMS products. Cloud vector winds from GMS received via the GTS are routinely used in upper air analyses and forecasts.

Part V PLANS FOR FUTURE OPERATIONAL SYSTEMS

Plans are currently underway to upgrade the present system to utilise the stretched VISSR digital data from GMS-3 when they are available in mid 1988.

Part VI VALIDATION AND VERIFICATION OF SATELLITE DATA AND DERIVED PRODUCTS IN OPERATION, INCLUDING PERFORMANCE STATISTICS

Nil.

Part VII CONTACT

Paul Lo
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Meteorological Service
Singapore.
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Singapore Changi Airport
Singapore 9181.

SPAIN

PART I. SUMMARY.

The Spanish National Meteorological Institute (INM) continues the development of its Meteorological Surveillance System (SIVIM) in order to improve the understanding of mesoscale weather systems and to meet user requirements for short-term forecasting, as it was described in the previous year.

PART II. MAJOR RESEARCH AND DEVELOPMENT IN THE APPLICATION OF SATELLITE DATA.

During 1986, studies on Meteosat imagery characteristics of several cloud structures, affecting to the Iberian Peninsula, has been carried out. The results of these studies are described in the papers "Mediterranen Coverture Complexes as viewed by Meteosat imagery: A case study" and "The role of Meteosat in the Spanish Weather Surveillance System", presented at the 6th Meteosat Scientific Users Meeting, held on Amsterdam (25-27 November 1986).

In addition, some activities related to the adaption of the "TOVS Export Package" (provided by the SSEC, Univ. Wisconsin) have been started.

PART III. DEVELOPMENT TECHNIQUES AND APPLICATIONS OF SATELLITE DATA.

As it was described in the previous year, the INM is developing a Meteorological Surveillance System (SIVIM), which is composed of different systems, fully integrated, with access to all types of meteorological information. One of the main components of SIVIM is the adquisition and processing of satellite imagery system (SAIDAS). This is formed by a receiving and pre-processing subsystems for Meteosat (raw data and PDUS), TIROS-NOAA (HRPT, TOVS included) and GOES-E. The data processing is based on the McIdas III software developed at SSEC/Wisconsin Univ.

During 1986 the main part of the McIdas III software package has been installed in the host computer (Fujitsu M-382) at Madrid. Different modules have been tested and adapted to the Spanish framework. In particular, the access to outputs from different numerical models and to conventional data has been performed.

Additionally, six McIdas terminals have been installed preoperational at Madrid.

PART IV. SATELLITE APPLICATIONS IN OPERATIONAL USE IN 1986.

The nine APT/WEFAX receiving stations (described in the previous year) installed at the National Centre and in different Regional Centres have been fully operational during 1986. The satellite images have been used mainly for forecasting with particular emphasis on nowcasting and short term forecast. These images have proved to be an essential tool for forecasting of the severe weather phenomena produced over the mediterranean area during last fall.

PART V. PLANS FOR FUTURE OPERATIONAL SYSTEMS.

During 1987 is expected to complete most of the SAIDAS impelmentation. The main activities to be performed will be:

- To install the antenna/receiving systems for Meteosat (raw data and PDUS), TIROS-NOAA (HRPT) and GOES-E (VISSR/VAS).

- To install 8 remote McIdas terminals, connected to the host computer (Madrid), in different Regional Centres.

- Integration of satellite imagery, meteorological conventional data and forecast fields in the McIdas system.

- To connect SIRAM and SAIDAS to start performing radar-satellite combination.

In addition, during 1987 it is intended to define a basic network of lightning locations systems.

Next years will be devoted to complete the weather radar network installation. Also, tasks referred to new software developing and testing and to integration of systems will be carried out.

PART VI. VALIDATION AND VERIFICATION OF SATELLITE DATA.

No activities in this field.

PART VII. OTHER ITEMS.

Contacts.

- Bartolomé Orfila.
  Meteorological Development Deputy Director.

- Antonio Labajo.
  Computer Division. Meteorological Development Subdirection.

- Concepción Martínez, José Juega.
  Satellite and Radar Division. Meteorological Development Subdirection.

- Angel Rivera, Ricardo Riosalido.
  Analysis and Forecasting Techniques Development Division. Forecasting and Meteorological Surveillance Subdirection.

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Spain.

SUDAN

PART I - SUMMARY

The main work continued to be directed towards improved utilization of satellite imagery to support forecasting techniques . During the rainy season images were used to track rain - producing systems. The quality of forecasts improved considerably .

PART II RESEARCH AND DEVELOPMENT

NIL .

PART III TECHNIQUES DEVELOPMENT

Satellite imagery has been applied mainly to synoptic analysis and forecasting . Images obtained every- Three hours using the visible infra - red and water vapour channels were used to assess and delineate potential convertive areas. The disturbances were found to move progressivly westward. From successine images it was possible to forecast areas to be affected. Using the same technique areas of blowing dust can be identified and the spreading of dust can be assessed from comparison of subsequent pictures .

PART IV SYSTEM OF SATELLITE APPLICATIONS

A DORNIER (SDUS) APT/ WEFAX .

Station located at the National Meteorological Centre at Khartoum Airport is operational . The attached video display unit can perform funtions such as zooming and movie - loops .

PART V - PLANS FOR FUTURE OPERTIONAL SYSTEMS

Plans include :

1- Adapting the existing APT/WEFAX station to be used in connection with METEOSAT MDD capability .

2- Acquisition of stand - by equipment as aback - up to the existing station .

PART VI VALIDATION AND VERIFICATION

NOT APPLICABLE .

PART VII : OTHER ITEMS

Scientists in change .

1- Mr. Eltayeb Musa Mustafa .

2- Mr. Ali Saad Mohamed Salih .

SWEDEN

Part I Major highlights

The PROSAT system (Processing systems for meteorological satellite data) was not delivered during 1986 as planned. The original hardware and software was changed to more powerful equipment. The system will be installed in stages and a first installation comprising an interface to a VAX 8600, image processor and two interactive work stations was completed at the end of the year. This will allow method developments with non real-time data.

Image presentation and processing systems to four regional weather offices have been purchased from the same manufacturer as for PROSAT. The systems will be installed during 1987 and 1988.

A PDUS antenna and receiving system was installed at SMHI during the spring. It will inguest digital Meteosat data into the PROSAT system.

Within the PROMIS project (Programme for an Operational Meteorological Information System) the development of operational classification methods for clouds and precipitation has been continued. NOAA AVHRR-data have been used and a model combining pixelwise multispectral classification with texture analysis has been defined.

Development work with TOVS data has continued. The International TOVS Processing Package, version 3 has been implemented and refined. Preparations for real-time TOVS data processing have been carried out.

For hydrological applications development of land-use classification methods have been started using LANDSAT MSS and TM data. Mapping of lake and flooded land areas has also been started.

Within oceanography and marine meteorology preparations have continued for the operational use of the PROSAT system.

The Swedish preparations for ERS-1 have continued with special emphasize on sea ice. The major efforts have been on increasing the understanding of the SAR and the Altimeter return signals from low salinity sea ice, and the preparations for an international field experiment in the Gulf of Bothnia in 1988.

Part II and III Research and develoment and techniques development

Cloud classification using multispectral signatures and texture analysis

An objective method for cloud analysis and classification from NOAA AVHRR data using simple box classification technique was proposed by Liljas (1984). Low clouds like cumulus, stratocumulus and stratus cannot be separated by this method. Cloud classification during night time is difficult but the use of channels 3 (3,7 μm) and 4 (11 μm) admits cloud separation to some degree, Liljas (1986).

Using spatial structure or texture derived by computing mean values and variances of the radiances cumulus and stratocumulus can be separated, Frisén and Ugnell (1986).

A model combining pixelwise multispectral analysis and texture analysis has been developed. The model has been tested for summertime and daytime conditions only with realistic results. The work continues together with normalization of radiance data and implementation of classification models on the PROSAT system.

Vertical temperature profiles

A software package, "The International TOVS Processing Package, version 3 (ITPP3)" developed by the Cooperative Institute for Meteorological and Satellite Studies (CISS), Madison, Wisconsin, has been implemented and tested on the main computer system at SMHI. The software will be used as a basic system in a later operational system for TOVS-data processing. Meso-scale and regional weather forecasts will be two applications of TOVS-data.

The retrieval method in ITPP3 has been refined. TOVS-profiles will be used in limited-area model (HIRLAM) under development. The work in this area started during the autumn 1986.

Ocean circulation patterns

Sweden participated in an international patchiness experiment (PEX) carried out in the central Baltic proper. Satellite data from NOAA AVHRR and LANDSAT TM were processed and used together with SLAR and IR scanner data to provide detailed information on the surface patterns.

Sea ice

Mapping of sea ice in arctic regions have been made as part of a research programme aimed at improving the ice information service to ships operating in the arctic.

Hydrological mapping

LANDSAT MSS and TM data have been used for developing land-use mapping procedures for a test region in southern Sweden. It has been possible to successfully map land-use categories such as different types of forest, cultivated land, swamps, water and urban areas. The distribution of the various land-use categories is related to catchment areas. This information will then be used in hydrological run-of forecast models.

LANDSAT TM data have also been used to map flooded areas. The extent of the flooded areas is related to the actual water level which will allow the extent of flooded areas to be forecasted when forecasting the water level.

Data collection

Data collection from two mountain stations has continued using the ARGOS system.

Swedish preparations for ERS-1

These preparations are following the plan described in the Annual Progress Report for 1985 though more emphasize has been placed on sea ice studies. Internationally Sweden has joined the Programme for International Polar Ocean Research (PIPOR) and submitted a proposal to ESA for geophysical validation and applications demonstration on sea ice in the Baltic using ERS-1 data.

Preparations have also been made for an international remote sensing experiment in the Gulf of Bothnia in 1988 called BEPERS-88.

Part IV Systems for satellite applications in operational use in 1986

Images from NOAA APT, METEOSAT SDUS and Meteor have been received at the central weather office. Photographic hard copies have been used operationally for mapping clouds, weather systems and sea ice in the areas surrounding Sweden.

Images have also been transmitted to regional weather offices via simple faximile equipment and telephone lines.

A relatively simple but very efficient interactive processing system has been leased for non real time work. Also a more sophisticated processing system owned by the Swedish Space Corporation has been used occasionally.

Part V Plans for future operational systems

Central reception and processing

A qualified image processing system, PROSAT, will gradually be installed during 1987. The system will consist of antennas for NOAA HRPT data and METEOSAT PDUS, interfaces, a host computer (a VAX 8600 also used for other activities), image processor (TERAGON) and four interactive work stations each with a colour graphic display, alphanumeric terminal, tablet and mouse. Both real-time satellite data and archived data on magnetic tape will be handled.

Image data will be calibrated, registered, and map transformed. Multispectral processing, classification and other types of image processing will be performed both on a scheduled, operational basis and for non rela-time applications. The images will be presented on colour displays and on hardcopy devices with colour and black and white presentation. Products for transmission to remote users like regional weather ofices etc will also be created.

DCP-data from remote observing stations will be collected and processed. TOVS-data will be handled and processed with the software package mentioned above.

Output products

A variety of products are planned to be used, ranging from mapping of weather systems on both synoptic scale and mesoscale to sea and ice mapping and vertical sounding data products.

Regional use of satellite data

Image handling and processing systems will be installed at four regional weather offices during 1987 and 1988. The systems will have a MicroVAX as host and a TERAGON system for image processing and display. Satellite images (and also other kind of images e g from weather radars) will be received over landlines from PROSAT at the central weather office. AVHRR and PDUS image products will be used in the real-time operational work.

Use of satellite data in the PROMIS project

A prototype for regional weather office is being built at SMHI in Norrköping. Meteorologists will work in a highly computerized environment and use the TERAGON workstations. Satellite images will form one important input data source which will be combined with all other kind of information like lightning location data, radar data, results from surface analysis etc. An operational phase of the project will start in 1988.

Part VII Other items

Staff

Kurt Ehlert	Hydrological applications.
Lars Gidhagen	Sea Surface Temperature, circulation patterns, etc.
Bertil Håkansson	ERS-1 preparations.
Karl-Göran Karlsson	Meteorological applications.
Erik Liljas	Meteorological applications, such as cloud classification and precipitation mapping.
Mats Moberg	Oceanographic applications.
Sten Orrhagen	Systems hardware and software.
Jan Svensson	Vertical profiling (TOVS).
Thomas Thompson	Developments and applications within oceanography and hydrology in general and sea ice in particular.
Ingemar Udin	Processing systems for meteorological, oceanographic and hydrological applications.
Gunlög Wennerberg	Hydrological applications, observation and collection systems.

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S-601 76 Norrköping
Sweden

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SWITZERLAND

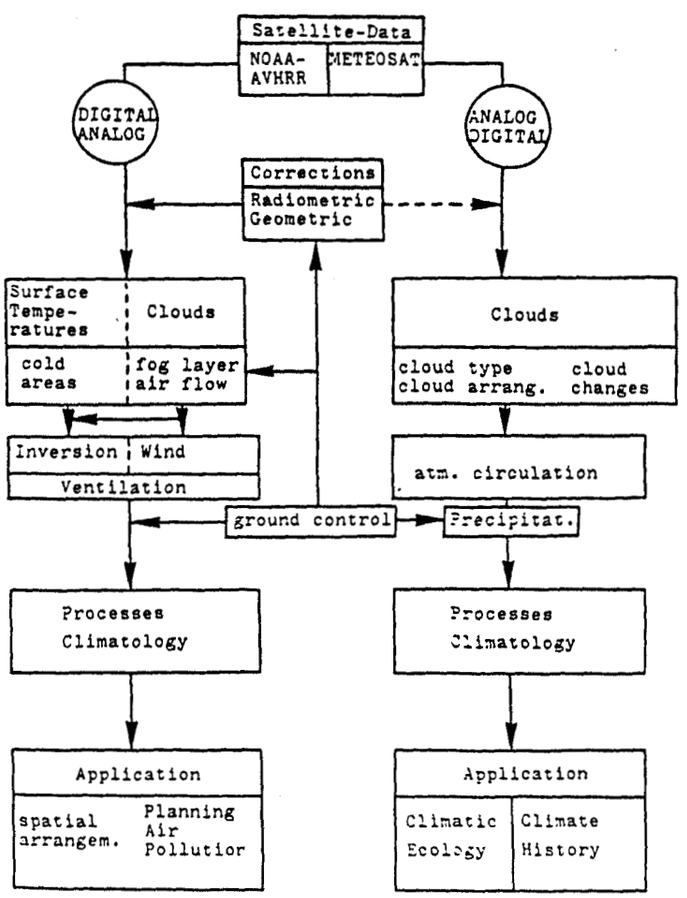
Part. I Summary of activities

During 1986 no new development has been initiated. The main activity was concentrated on the continuation of the already undertaken research work.

Part. II Research and development

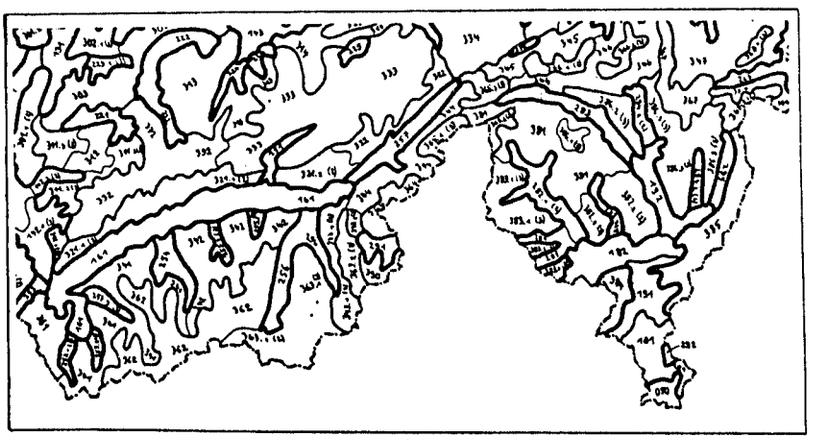
The same letter as in the previous reports will be used for the same item. No special report is given here if the research work is continuing.

c) The use of satellite-data in climatological programmes of the Geographic Institute of the University of Bern.



e) The following picture is giving an illustration of the undertaken work.

Section of the regionalisation of Switzerland into 173 convective-type "cloud-regions"



f) Solar energy resource assessment

Possible methods to predict hourly direct beam solar irradiance from satellite-estimated global irradiance and total cloud cover have been explored. Direct beam estimates are essential to models which calculate irradiance on slopes (e.g., tilted collectors, building façades). Several satellite-based models for horizontal global irradiance at the ground are available. Direct beam may be retrieved from global horizontal either via correlations between pertinent ground-based measurements, or via simple ground-based models which also use total cloud cover as input.

Tests have been carried out with estimates from GOES data (method by Tarpley, AGRISTAR project) and measurements from Albany, N.Y., resp. with estimates from METEOSAT data (method by Möser and Raschke, DWD project) and measurements from Geneva in Switzerland.

The ground-based model method proves to be superior to the mere correlation method, as would be expected from introduction of the variable total cloud cover.

(Zelenka, Swiss Meteorological Institute on behalf of the Swiss Federal Office of Energy and Atmospheric Sciences Research Center, State University of New York at Albany, N.Y. on behalf of the N.Y. State Energy R&D Authority).

g) Cryosphere

Microwave investigations for the interpretation of satellite data: Active and passive microwave signature studies on snow and soil have been conducted including the interaction of the electromagnetic waves with snow and soil for the development of algorithms to retrieve satellite data (7, 8, 11, 13). Results of these investigations become utilised in a follow-on "study on use and characteristics of SAR for land snow and ice applications" under ESA-contract, and they are at the basis of a cooperative Swiss proposal to ESA "ERS 1 AMI-Data for Snow Cover Estimation and Run-off Forecasting".
(Schanda, Institute of Applied Physics, University of Bern)

h) Snowmelt runoff

- Compilation of relative and absolute snow-melt maps for the test area Davos (classification of 28 Landsat-MSS scenes between 1976-1982).
- The snow-melt runoff model to forecast surface runoff in high mountains was made operational in simulation mode for the Felsberg-Rhein Test-Area (approx. 3'250 km2). The changes of the snow-cover for the different elevation zones are derived from Landsat-MSS data.
- Comparative study using analog and digital techniques to evaluate the possibility to supplement satellite data with high ground and low time resolution (Landsat), with data of high time resolution (NOAA-AHVRR).
  (Hafner, Geographical Institute, University of Zurich).

i) Middle atmosphere

Ground-based investigations of the height distribution of ozone and its diurnal variations have been performed with a millimeter-wave spectro-radiometer (5, 6) over several periods of at least several months each since 1981, and other atmospheric parameters (Zeman splitting of the mesospheric O_2-line (10) and H_2O height distribution) have been studied with air-borne mm-wave instruments. These studies are in preparation of the Millimeter-wave Atmospheric Sounder (MAS) presently in the final phase of construction. This instrument will for the first time measure simultaneously the height distributions of ozone, water vapor chlorineoxyde, temperature and pressure in the middle atmosphere (15-100 km) on global scale (12). The MAS is selected by NASA for inclusion in the ATLAS-mission program with a first flight in January 1991. The MAS is a joint project by Institute of Applied Physics, University of Bern, Switzerland; the Max-Planck-Institute for Aeronomy, Lindau, F.R.G.; Naval Research Lab., Washington, USA; Pennsylvania State University, Pennsylvania, USA.
(Schanda, Institute of Applied Physics, University of Bern)

j) Surface hydrology

In surface hydrology, rugosity is an important factor which determines the Rainfall-Runoff relationship. It is the most sensitive characteristic of watershed behaviour in hydrological simulation models.

"Thematic Mapper" images from Landsat satellites are used for the land cover determination. The rugosity which refered to the nature of the vegetation cover is identified with the use of a biomass algorithm. This derived information is then combined with other terrain characteristics and entered into simulation models that can be either global or rasterized.
(Musy, Agricultural Ingineering Institute, Swiss Federal Institute of Technology, Lausanne).

k) Sensing of the solar constant

This survey represent a major activity for the benefit of meteorological and climatological research work.

Space research at World Radiation Center (Davos) is concentrated on monitoring the solar irradiance outside the atmosphere: the solar "constant" SC (irradiance at 1 AU, integrated over the energetically important part of the spectrum) with highly accurate absolute radiometers and its spectral distribution with sunphotometers. The results are important not only for the understanding of the influence of varying Sun on the Earth's climate, but also for the understanding of the Sun itself.

Since 1979 four experiments from stratospheric balloons in co-operation with the Geneva Observatory and two from sounding rockets together with the Jet Propulsion Laboratory in Pasadena, California, have been successfully flown. The results of these experiments together with the continuous satellite data from the instruments on the Solar Maximum mission and the NIMBUS 7 spacecrafts demonstrated for the first time the reality of a downsward trend of the SC over the last 6 years.

Experiment packages with radiometers and sunphotometers are presently being built at PMOD/WRC for the PHOBOS mission to Mars of USSR, to be launched in 1988 and the first EURECA mission of ESA with a probable launch in 1989, if the present shuttle schedule holds. Moreover, the balloon and rocket program is continued in order to maintain the high precision needed for the detection and monitoring of the small, but climatologically relevant changes of the SC.
For METEOSAT 2nd Generation the WRC is involved in the planning of a scientific payload containing among others a solar irradiance monitoring experiment.
(Fröhlich, World Radiation Center, Davos).

PART II.2 Development

The interactive display terminals SARA, delivered at the end of 1985, have been taken into service at the regional forecasting offices. They have proven to be an excellent tool to the forecasters.

The PDUS receiving chain has been thoroughly tested and integrated into the existing system for satellite and radar data processing.

The Swiss users of real-time and archived data of meteorological satellites and radar have been interviewed about the future needs. Based on their answers new user products for real-time distribution have been defined, which should be introduced by and by.

PART III Application of techniques

- The distribution of stereopolar projection of METEOSAT 2 pictures is now operational.
- The software has been developped to get from any part of the METEOSAT imagery the corresponding stereopolar projection.
  (Swiss Meteorological Institute, Annexe Locarno)
- Development of methods and procedures to process remote sensing satellite data. Integration of multivariate image analyses into Geographic Information Systems.

  Areas of interest:
  a) Landuse mapping
  b) Snow cover evaluations to forecast snowmelt water runoff.
     (Seidel, Image Science Division, Institute for Communication Technology, Swiss Federal Institute of Technology, Zurich).

PART IV Description of operational Systems

The PDUS at Locarno is now operational. Except this, no change relative to the Report SAT-3 (1984).

PART V Future plans

The reception of NOAA TOVS data is now reported to 1989.

PART VI Verification of satellite data

No special work, see also Part II.1 c), f), i) and k).

PART VII References

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THAILAND

Meteorological Department

I. SUMMARY

(i) The Meteorological Department regularly receives both APT and HRPT pictures from polar-orbiting NOAA-satellites with high and low resolution WEFAXs from GMS-3 satellite.

(ii) Satellite images are routinely disseminated to the central weather forecast division, 3 regional weather forecast centers and 2 international airports.

(iii) The Satellite Receiving Station has been supplying sets of NOAA data tapes to be furtherly processed at the Cooperation Institute of Applied Meteorology at the University of Missouri, Columbia, USA till September.

II. RESEARCH AND DEVELOPMENT

NIL

III. TECHNIQUES DEVELOPMENT

- During the tropical storm season in 1986, enhanced infra-red pictures were produced for use in tropical storm intensity estimation by the Dvorak method.

IV. RECEIVING SYSTEM

A block diagram of the meteorological satellite APT ground reception system is shown below :-

- There are three types of antennas :

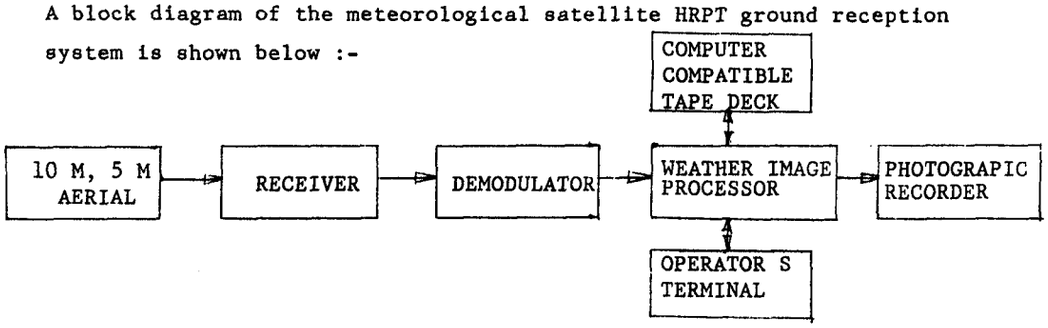
(1) A 2.5 m screen parabolic antenna to pick up SDUS signals from GMS.

(2) A cross yagi antenna, manual control, to pick up APT signals from polar orbiting satellite.

(3) An omni antenna to pick up APT signals from polar orbiting satellite.

- Both infra-red and visible cloud images can be selected.

A block diagram of the meteorological satellite HRPT ground reception system is shown below :-



- The 10 m and 5 m diameter parabolic antennas and the two receivers pick up the WR signals from the NOAA satellite respectively; such signals after demodulation and digitization, are recorded on a 9-track computer tape.
- The brain of the system is the Weather Image Processor (WIP) which is based on several Z-80 microprocessors. By mean of the WIP, the brightness levels of cloud features can be enhanced according to different Look-up Tables (LUTs) for a detailed study.
- Both infra-red and visible cloud images can be produced at different magnifications in photo-fax copies. Pictures produced by the facsimile recorder are in 16 shades of grey scale.

V. FUTURE PLANS

- The Department plans to have new equipment for receiving S. VISSR from GMS.

TUNISIA

Part I - Since 1985, the National Meteorological Institute in Tunisia has been equipped with a secondary data utilization station (SDUS; make: TECNAVIA) with a WEFAX reception system.

This system replaces the previous equipment, first installed in 1972 and improved in 1979. This was an APT/WEFAX station which is still in good condition and receiving pictures in the visible and infrared wavebands from NOAA and METEOR polar-orbiting satellites.

A third high-resolution radiometric station was purchased in 1980. Unfortunately it has not been in use, due to technical problems.

Part II - No applications at present.

Part III - The SDUS station receives images from the European satellite METEOSAT 2, in the three channels (visible, infrared and water vapour).

These data are mainly used to assist in general weather forecasting and to provide services for aviation.

The main users and user services are the general public (by means of the televised weather bulletin) and civil aviation (flight documentation).

Part IV - The present system in operational use in the National Meteorological Institute consists of a secondary station using WEFAX data, the main components of which are:

- A parabolic antenna (ϕ = 2 m)
- An SK9 micro-computer (storage of up to 16 images, animation, zooming, etc.)
- Colour VDU
- Four black and white terminals, one of them local; the other three are installed at the airports at Tunis-Carthage, Monastir and Jerba, respectively.

Part V - A project concerning an application to an agrometeorological model of a cereal is intended to make use of remote sensing data to estimate the trend of the phenological phases, and to estimate the areas sown with crops.

- In order to achieve this objective, we have the promise of co-operation with the Ministry for Scientific Research, the National Institute of Statistics and the Ministry of Agriculture.

  A project for assistance from the Centre National de la Recherche Scientifique Français was requested in 1986.

- Participation, under the Commission for Locust Control in Northwest Africa (C.L.C.C.P.A.N.O.-FAO) in monitoring and checking locust activity.

- Following the visit of the WMO expert, Mr. Van Hamme, a national project will be set up after the meeting of representatives of this Commission in Algiers (April 1987) (14th Session).

Part VI and VII - No applications, at present.

TURKEY

Turkish State Meteorological Service

PART I :

The images in anolog and Wefax forms have been taken by the ground receiver equipment from the geostationary METEOSAT, polar orbital TIROS-N, and METEOR series satellites in 1986. These products taken by the ground receiver are used for forcasting and synoptic analysis. The present APT system has 32 images memory capacity. These images stored at the device gives a general information of the movement of the preasure centers and the frontal systems. This system produces the other meteorological parametres such as cloudness, ice and snowcover, cloud-top's temperature as well. The data produced in the analog format are interpreted subjectively. All these products are essential tool for daily weather forecast, and widely used.

PART II:

The studies on cloud movement vectors are going on. The research program for development of the satellite data production and usage are being planned.

PART III.IV :

The amount of precipitation can be predicted with the aid of the cloud brilliance and cloud-top's temperature obtained from the present system, and their relations with synoptic models.

ALDEN APTS-3/B receiver set derives information from the geostationary METEOSAT, polar orbited TIROS-N, and METEOR series. The apparatus listed belowe are connected with the system to obtain much more profit in December 1986.

Tecnavia SK-8011/RU/8 Receiver	(1 unit)
Monitor	(2 unit)
APT colored Computer	(8 mbyte)
RGB Colored therminal	(1 unit)
RGB Pal Converted	(1 unit)
Puls-Generator	(1 unit)
TV sound Modilator	(1 unit)
Sony camera	(1 unit)
Sony U-matic Video Recorder	(1 unit)

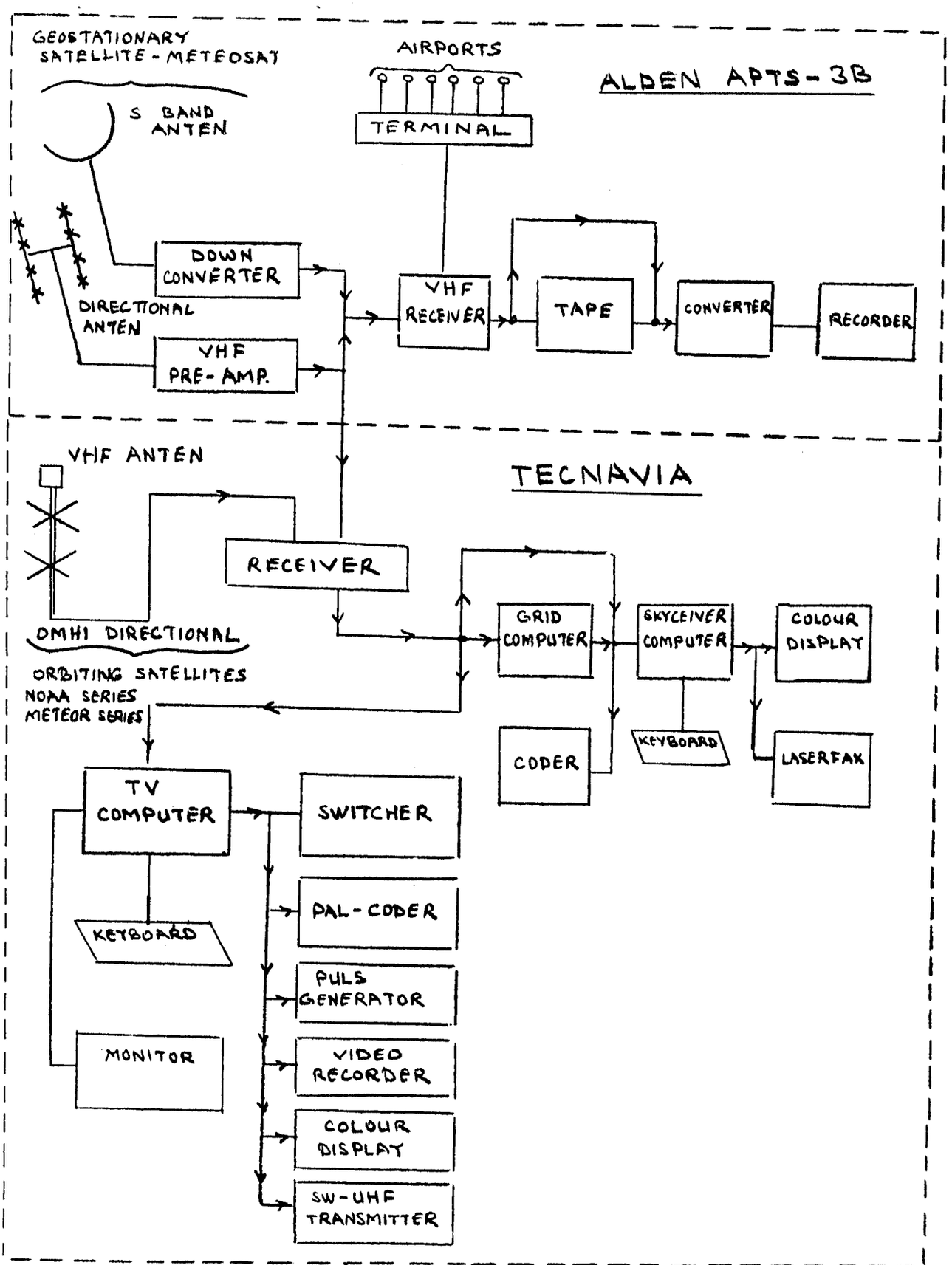
In addition, The present system's memory capacity has been reached from 2 Mbyte to 4 mbyte. A block diagram of the system being Used is attached herewith in the Annex A.

PART V :

Since the resolution of the system alread operated is about 4 kms. It is unable to study for hydrological purposes.

PART VI.:

There is no any statistical method to apply for the verification of data and derived products.



A BLOCK DIAGRAM OF THE METEOROLOGICAL SATELLITE GROUND RECEPTION SYSTEM

ANNEX A

UNITED KINGDOM

UK Meteorological Office

PART I: A brief summary of the major highlights of research applications and operational changes

1. The TIROS Operational Vertical Sounder (TOVS) data have continued to be received locally and processed in real-time for use by the global and regional atmospheric models. The major charge was the introduction late in the year of a new cloud clearing scheme.

2. The FRONTIERS system which enables forecasters to use radar and Meteosat imagery for the analysis and forecasting of rainfall, was declared operational during November and is now operated around the clock. Development continues.

3. Several studies and development contracts have now been completed on the design of the Advanced Microwave Sounding Unit (AMSU) to be provided by the Meteorological Office for the TIROS-N satellites during the 1990s.

4. The Meteorological Office continues to increase its use of the Data Collection Systems available on the geostationary and polar orbiting satellites, and has expanded the number of observing systems deployed on ships, buoys and platforms which use these services.

5. Development work on the focal plane assembly for the Along Track Scanning Radiometer (ATSR) to fly on the ERS-1 satellite in 1990, making very accurate measurements of sea surface temperature, has continued. This unit will be supplied to the Rutherford Appleton Laboratory for assembly into the main instrument.

PART II: A description of the major research and development in the applications of satellite data, derived products and services

1. Research within the Meteorological Office into the uses of high resolution, digital satellite data is based around the HERMES and HOMER computer systems at Bracknell and Oxford respectively. These two systems consist of DEC VAX 11/750 minicomputers with SIGMEX Advanced Raster Graphics Systems (ARGS) for the display of imagery and derived products. The computer systems are used for research into the derivation of atmospheric soundings from TIROS Operational Vertical Sounder (TOVS) data and the possible applications of high resolution satellite imagery. The HERMES computer also processes the TOVS data on a routine basis, with the soundings being used by the operational atmospheric models.

2. The HERMES (High Resolution Evaluation of Radiances from Meteorological Satellites) system was procured in 1983 with the primary aim of developing the capability for deriving high resolution atmospheric soundings from TOVS data in a timely fashion. The raw TOVS data are received at Lasham and transmitted to Bracknell over a telephone line for processing on HERMES. Up to 14 passes of TOVS data can be received each day when two satellites are operational, with the processing into atmospheric soundings taking around 40 minutes per pass. Over 500 soundings can be produced from each pass with a horizontal resolution of about 80 km. The soundings are used in both the global coarse-mesh and limited area fine-mesh versions of the atmospheric model. (Mr R Allam, Mr D Chapman)

2.1 A new cloud clearing scheme has been developed and tested successfully. It achieves improved clear radiances with a sequential estimation technique which makes use of the horizontal consistency expected in the clear radiance fields. It was introduced into the routine processing during 1986, (Dr J Eyre, Mr P Watts), and is currently under assessment (Mr P Dibben, Mr J Ricketts)

2.2 A new inversion scheme, which takes a "first guess" profile from the fine-mesh forecast model and uses the expected vertical error covariance of the forecast profile to constrain the inversion, is under development. The theoretical performance of such a scheme has been assessed. (Dr J Eyre). It is hoped to introduce this scheme during 1987.

3. Development has continued on a scheme for generation of quantitative products from AVHRR data, at the 15 km resolution of the mesoscale model currently under trial within the Office. The list of products under test include surface temperature, surface albedo, various cloud parameters and snow/ice cover. There are now separate schemes for use during the day and night, with different procedures for use over land, sea and coastal areas. (Dr R Saunders)

5. The FRONTIERS project has been under development for a number of years with the goal of using surface radar data and digital satellite imagery to produce detailed analyses and short period forecasts of precipitation over the UK. During 1985 the prototype FRONTIERS system and the dedicated Meteosat PDUS receiver were moved from Malvern to the Meteorological Office headquarters at Bracknell, prior to the system being used operationally from 1986. A second DEC VAX 11/750 computer was procured to act as a backup for the operational FRONTIERS processor and also to allow further development of nowcasting systems. This second system, known as MERLIN, is now being used for improving the operational software suite implemented in the FRONTIERS computer. FRONTIERS was declared operational during November, although at present only the radar composite pictures optimized by the forecaster operating the system are disseminated. It is hoped to begin regular assessment of the precipitation forecasts early in 1987. Work has begun to incorporate data in real-time from the new radar in Northern Ireland due to become operational in Spring 1987. (Dr B Conway, R Brown)

6. The effort within the Meteorological Office on the development of satellite instruments has continued at a high level. The main developments during 1986 are described below:

6.1 The support for the US polar-orbiting satellites continues through the provision of a total of 9 Stratospheric Sounding Units (SSU) and the development of the Advanced Microwave Sounding Unit B (AMSU-B). The SSU F2 launched in June 1979 continued to provide stratospheric soundings. SSU F5 on NOAA-9 also continues to provide stratospheric sounding data, however the noise on channel 27 has now gone outside specification. A dummy SSU was launched on NOAA 10 to ensure that enough SSUs remain to provide overlap of infrared stratospheric soundings with the replacement microwave technique provided by AMSU-A to be first flown to NOAA-K. Consequential on the failure of a development model pressure modulator cell (PMC) in the upgraded development model, the facilities for repair of the pmc have been recommissioned. A flight model pmc has been reconstructed. This pmc passed its vibration qualification test and leak test.

Research using SSU data has continued within the middle atmosphere group in the dynamical climatology branch. This group are preparing a satellite data assimilation scheme for a three-dimensional model of the stratosphere and mesosphere which will form part of the Upper Atmosphere Research Satellite (UARS) project. (Dr A O'Neill)

6.2 The UK/USA programme leading to the provision of AMSU has continued. The AMSU-A instrument, which provides temperature sounding data from the surface to 1 mbar, will be provided by NOAA through a contract with Aerojet. The UK has agreed to provide the B unit, which will provide humidity profiles and maps of non-ice clouds and precipitation. The hardware development contract with MDS continues. A Preliminary Design Review has been held. Sufficient work has been done to define the layout and provide accurate estimates of the performance, mass and power budgets. Tests on components as they become available indicate that performance should be met. A 90 GHz mixer has at a second attempt survived component level vibration qualification. The only vibration test on a whisker contacted device resulted in failure, the review board criticised the poor quality assurance aspects of the construction. These aspects are being addressed. A parallel development programme at RAL on the Microwave Limb Sounder programme has successfully developed several such devices to space standard and provides a possible assured second source.

Two other contracts were placed with industry for them to provide detail cost estimates and technical feasibility studies. The technical work has been completed and was reviewed by the Office with support of consultants from RAE and RSRE. NOAA and NASA representatives also attended to advise and agree on spacecraft interference matters. The technical aspects are in general satisfactory, with the exception of some redesign needed on the basic structure to reduce load amplification on subsystems and a review of the mechanism life estimates. The programme aspects and financial aspects were not acceptable on budgetary grounds and the contracts with BAe and MSS were extended to revise these aspects. A small contract was also awarded to Aerojet to evaluate the costs associated with modifying the USAF unit on their Defence Military Satellite to achieve the AMSU-B specification. (Dr D Pick)

In parallel with the industrial effort on AMSU-B the Office is developing a supporting scientific programme. This work has two facets. Firstly radiometric calibration, an in-house AMSU-B calibration facility has been costed and an accommodation bid prepared. Design work on the internal and external microwave calibration targets has been undertaken in the Office with support from Bath University and NPL. A test sample of the internal target demonstrated acceptable performance. A test rig for a full size target has been designed.

Secondly spectroscopy aspects. An experimental programme is underway involving the Rutherford Appleton Laboratory and the Laboratorie de Meteorologie Dynamique at Palaiseau. The equipment has been set up and measurements at AMSU-B frequencies have been made on the microwave properties of water in its three phases. A supporting measurement programme for atmospheric measurements has also been initiated again in collaboration with LMD. The MRF C130 has been modified to support an external pylon arrangement which will carry a French provided pod housing a scanning mirror. Inside the aircraft a two channel radiometer will be mounted, a contract has been awarded to MSS to provide this. (Dr D Pick, Mr S Stringer)

On the data side the data required for postlaunch evaluation and utility of the observations has been specified and negotiations started with NOAA. The assessment of the humidity retrieval schemes has been done at the Hooke Institute and was reviewed at a work shop in Boston arranged by the USAF. (Dr J Eyre)

6.3 The Office are collaborating with the Rutherford Appleton Laboratory, Oxford University and Mullard Space Science Laboratory in the provision of the Along the Track Scanning Radiometer (ATSR) for the European Space

Agency (ESA) satellite Earth Resources Satellite 1 (ERS-1). This radiometer is due to fly in 1989 and will provide measurements of sea surface temperature to an accuracy of better than 0.5 K. The Office is responsible for the detail design of the detector assembly in the focal plane of the ATSR viewing telescope. The engineering model focal plane assembly has been assembled and passed its vibration test. The thermal design has been validated. A specially equipped clean room has been commissioned and an alignment facility set up. Test targets have been made and the associated electronic equipment is in the process of evaluation. Calibration targets for ATSR have been designed and are under construction in the Met Office work shops. A contract for procurement of the target controller through industry has been authorised.

7. The Office has participated in the development of algorithms for the ESA wind scatterometer that will be flown on the Earth Resources Satellite (ERS-1) due for launch in early 1990. Studies for the UK ERS-1 data centre at the Royal Aircraft Establishment, Farnborough were completed with initial specification of data sets, data flows and algorithms. A contract with ESA for a limited feasibility study of a near real-time operational quality control and real-time validation scheme involving numerical model real-time data has been agreed. (Mr D Offiler)

8. The Office has responded to an invited issued by ESA for proposals for studies of the use of data to be produced from the ERS-1 satellite. The surface wind and wave data which will become available in near real-time when the satellite is launched at the end of the decade are of particular interest for forecasting. Preparatory work is now beginning with a number of impact studies to assess the effect of these data on numerical weather prediction models. (Dr R Bromley, Dr P Francis)

9. During the year there was continued interest, both nationally and internationally, in the polar platform concept which has been proposed to replace the polar orbiting satellites in the 1990s. Office staff served on a number of groups concerned with examining the basic concept of the platform and the possible instruments which could be carried.
(Mr C Collier, Dr D Pick, Dr J Eyre)

10. The Synoptic and Mesoscale Research Group has continued research into weather systems around the UK using radar and digital satellite data.
(Mr M Bader)

PART III: A description of techniques development and applications of satellite data, derived products and services

1. Products derived from satellite data has continued to play a vital role in the operational numerical weather prediction system used by the Meteorological Office. Cloud track winds from the geostationary satellites and atmospheric temperature soundings in the form of global SATEMs and locally derived high resolution soundings are used routinely in the production of numerical analyses. Sea surface temperatures are also important to the forecasting system and satellite measurements are used in conjunction with in-situ data in maintaining a current global SST field for use by the numerical models in deriving surface fluxes over the oceans.

2. The Data Collection System (DCS) on the geostationary satellites and the ARGOS service on the TIROS-N satellites provide important means of collecting observational data from remote regions. The Office is currently using these services in a number of observing systems.

2.1 The Meteorological Observing System for Ships (MOSS) allows the rapid collection of data from merchant vessels of the Voluntary Observing Fleet via the international channels of the geostationary satellites. Eight systems have now been installed and a further 10 systems were delivered at the end of 1986. An additional 10 systems are now on order and delivery is expected in late 1987.

2.2 To support the marine forecasting services provided by the Office a network of tethered data buoys is being established around UK waters. These will use both ARGOS and DCS and provide rapid delivery of surface observations to Bracknell. At present the ODAS 20 buoy is located at 55°20'N 2°20'E using both ARGOS and DCS, and the joint French/UK BOSCO buoy is located at 51°N 14°W using ARGOS.

2.3 The oil and gas rigs in the North Sea provide excellent platforms for the routine collection of meteorological data in a region poorly covered by conventional observing systems. Systems based on MOSS have been deployed on the Viking Alpha platform and the BP Forties platforms. These systems will provide their observations through the Meteosat DCS service.

2.4 Following the trial of an Automated Shipboard Aerological Program (ASAP), upper air observing system on the vessel CP Ambassador during 1984 two ASAP systems will be procured for routine use during 1988. However, it is likely that one system will be leased for operation during 1987.

PART IV: A brief description of the system for satellite appalications in operational use in 1985

1. Most of the satellite imagery used operationally within the Meteorological Office is received at the ground station at Lasham in Hampshire, and processed at Bracknell before being disseminated to users throughout the country. The Lasham site receives the Meteosat WEFAX, NOAA APT and GOES-EAST WEFAX data along with selected AVHRR imagery, which is then transferred to Bracknell via telephone lines. The imagery is digitised and processed on the dual AUTOSAT computer systems (DEC PDP 11/60 computers) before being disseminated via landline to the outstations on the SATFAX network.

PART V: Plans for future operational systems for satellite applications to meteorology and operational hydrology

1. During the next few years the Meteorological Office are planning to make increasing use of digital satellite imagery data in its operational work at headquarters and the outstations. These data, such as the TIROS-N AVHRR and Meteosat PDUS data streams, give increased horizontal resolution and additional spectral channels, and allow the derivation of many new meteorological parameters. A project team has been established to procure the computing system required to process these high speed data and the means of interfacing with the new Weather Information System (WIS) and Outstations Display System (ODS) which are under development.

The system known as AUTOSAT II was specified during 1986 and procurement action has now begun. (Mr R Allam)

PART VI: Validation and verification of satellite data and derived products used in operations, including performance statistics

1. The soundings from the Local Area Sounding System (LASS) along with the SATEMs available over the GTS are compared against collocating radio sonde ascents on a routine basis and validation statistics derived. During the year the analysed LASS data have continued to be compared against numerical analyses interpolated to the time of the overpass to help in the analysis of various problems associated with the sounding data. In particular, work began to assess the new cloud clearing scheme.
(Mr R Allam, Mr P Dibben, Mr N Ricketts, Mr D Chapman)

PART VII: Other items (references, publications and the names of scientists in charge, etc)

1. Relevant publications during 1986

Allam R J
"On a slight mis-registration of AVHRR channels 3 and 4"
Int J Remote Sensing, 1986, Vol 7, No 7, pp 887-894.

Cavanie, A and Offiler, D
"ERS-1 wind scatterometer wind extraction and ambiguity removal"
Proceedings of IGARSS '86; Todays solutions for tomorrows information needs. Zurich, Switzerland, 6-9 October 1986. ESA SP-254, August 1986, pp 395-398.

Chedin, A, Pick, D, Rizzi, R and Schluessel, P
"Second-Generation Meteosat Definition Studies on Microwave and Infrared Vertical Sounders"
ESA STR-219, September 1986.

"Second-Generation Meteosat enhancement of IR sounder"
ESA Study Report, October 1986.

Eyre, J R
"Estimation of sea-surface temperature from AVHRR data; comments on the paper by Singh et al (1985)"
Int J Remote Sensing, 1986, Vol 7, No 3, pp 465-469.

"On systematic errors in satellite sounding products and their climatological mean values"
Quart J R Met Soc, January 1987, 113, pp 279-292.

Eyre, J R, Pescod, R W, Watts, P D, Lloyd, P E, Adams, W and Allam, R J
"TOVS retrievals in the UK: Progress and plans"
Presented at the Third International TOVS Study Conference at Madison, Wisconsin, USA, August 1986.

Offiler, D
"The use of aircraft for wind scatterometer calibration"
Proceedings of Conference on ERS-1 wind and wave calibration, Schliersee, FRG, 2-6 June 1986. ESA SP-262, September 1986, pp 131-134.

Pescod, R W, Saunders, R W and Eyre, J R
"Sea surface temperature images from Advanced Very High Resolution Radiometer (AVHRR) data"
Meteorological Magazine, 115, 1986, pp 318-325.

Pick, D R
"The operational sounding of the lower atmosphere from satellites using millimetre waves"
Proc 16th European Microwave Conference, Dublin, September 1986.

Ricketts, J N
"Unusual wave clouds over Northern Scotland"
Meteorological Magazine, Vol 115, No 1362, pp 10-17.

Ricketts, J N, Allam, R J and Turner, J
"The use of direct readout, high resolution TOVS data in short and medium range weather prediction"
Presented as COSPAR, Toulouse, France, July 1986.

Saunders, R W
"An automated scheme for the removal of cloud contamination from AVHRR radiances over western Europe"
Int J Remote Sensing, 1986, Vol 7, No 7, pp 867-886.

"Retrieval of surface and cloud parameters from AVHRR/2 data"
Preprint Vol, 6th Conference on Atmospheric Radiation, Williamsburg VA, USA, 13-16 May 1986.

"The impact of clouds on remote sensing of surface and atmospheric variables"
Int Meeting on Atmos Transparency for Satellite Applications, Capri, Italy, 15-19 September 1986.

"Detection of cloud-free and cloud-filled AVHRR/2 fields of view"
1st Australian AVHRR Conference, Perth, Western Australia, 22-24 October 1986.

Turner, J, Allam, R J and Maine, D R
"A case study of the detection of fog at night using channels 3 and 4 on the Advanced Very High Resolution Radiometer (AVHRR)"
Meteorological Magazine, Vol 115, No 1370, pp 285-290.

Watts, P D and Eyre, J R
"Validating a TOVS clearing scheme using AVHRR data"
3rd Int TOVS Study Conference, August, Madison, Wisconsin, USA.

USA

PART I. SUMMARY OF HIGHLIGHTS

1.1 EL NINO AND THE SOUTHERN OSCILLATION

Multi-Channel satellite-observed Sea Surface Temperature (MCSST) observations from October to mid-December showed patterns similar to those associated with the El Nino-Southern Oscillation. The 1986-early 1987 event, however, was much weaker than the 1982-83 event. Scientists believe that the El Nino brings about large-scale climatic observations by adding extra heat to the atmosphere from the warmer than normal oceanic waters.

1.2 GOES VISSR ATMOSPHERIC SOUNDER (VAS) RESEARCH

Nineteen eighty six was the final year of research and development for VISSR Atmospheric Sounder VAS products. Routine processing by the NESDIS Office of Operations at the Suitland VAS Data Utilization Center begins in 1987. In 1986 product support was directed principally to the National Severe Storm Forecast Center and to the National Hurricane Center. Emphasis in the final year of development was placed on simplification and automation. Man interactive functions in the processing of soundings were replaced (though not eliminated) by objective algorithms with the result that the operational duty cycle was reduced from 3-hourly to every 90 minutes. This added temporal continuity was well received at NSSL, especially as the products became available 7 days a week.

Considerable emphasis was put on developing the water vapor tracking software to measure the accuracy of wind fields derived for the NHC. This remains an operator interactive procedure, but the integration of "first guess" estimates from numerical analysis and forecasts from the National Meteorological Center has greatly reduced the training period for new operations and the variance between winds produced by different operators. In addition, winds are now derived from both the 6.7 and 7.2 micrometer channels, the later adding to the information at mid-levels which is critical to hurricane track forecasting. These data have been shown in case studies to have a strongly positive impact.

Field program support was again offered and the VAS was used extensively in the Genesis of Atlantic Lows Experiment, the Cooperative Huntsville meteorological experiment and the First ISCCP Regional Experiment during 1986. (C. Hayden)

1.3 ATMOSPHERIC TEMPERATURE AND MOISTURE SOUNDINGS

The year 1986 marks the seventh year of atmospheric sounding production from the NOAA polar orbiting satellite system (using the HIRS/2, MSU, and SSU instruments). In April 1986, a major improvement was made in the sounding processing system with the implementation of the TIROS Operational Vertical Sounder (TOVS) Enhancement Sounding System. The Enhancement System produces soundings at a higher horizontal resolution (80 km versus the 250 km resolution of the system replaced) in meteorologically active areas, thus providing additional temperature and moisture information where it is most needed. This increase in resolution has been accomplished without compromising data accuracy. Soundings processing efficiency has steadily improved in the last few years with the arrival of new and upgraded computer facilities at the NESDIS and the NWS. Soundings are typically being made available to the user community within 1 hour and 20 minutes of satellite data readout, an improvement of at least an hour over delivery times prior to October 1985. User interaction and feedback continue to indicate increased confidence and reliance on satellite soundings by the user community. (A. DeCotiis)

1.4 OPERATION OZONE MEASUREMENT

As part of the NOAA commitment to Public Law 95-95 of the Clean Air Act, remote sensing of atmospheric ozone began in January 1985, shortly after the launch of the NOAA-9 polar satellite. Global atmospheric ozone is passively sensed by the Solar Backscatter Ultraviolet Radiometer (SBUV/2) on the afternoon polar orbiting NOAA satellite. Generation of operational total, level, and layer ozone observations began in 1986. These products are provided to the NASA Goddard Space Flight Center, NOAA Environmental Research Labs, and the Atmospheric Environment Service (AES) of Canada.

Unforseen instrument behavior detected during the Analysis and Evaluation activities conducted immediately after the launch of NOAA-9 has made necessary a modification to the operational ozone processing system to correct false assumptions concerning the linearity of the SBUV/2. In 1987, after completion of this modification and after implementation of snow and ice information into the product processing, all SBUV/2 data collected since the launch of NOAA-9 will be reprocessed with the latest operational algorithm. After reprocessing, the SBUV/2 ozone products will be consistent with research data from prior SBUV instruments, and can be used to determine man's influence on the stratospheric ozone layer. (D. Bowman)

1.5 SEA SURFACE TEMPERATURES

Observations of sea surface temperature (SST) at 8 km resolution for the world's oceans continue to be produced from polar orbiting satellite infrared data. Observations are transmitted to the Ocean Products Center (OPC) of the National Meteorological Center, to the Navy Fleet Numerical Oceanography Center (FNOC), and to World Meteorological Organization users via the Global Telecommunications System for use in production of oceanographic and meteorological products. A variety of sea surface temperature digital analyses and hardcopy charts are produced at the OPC and FNOC from either satellite data only or a combination of satellite data and conventional ship and buoy observations. On January 1, 1986, new local-scale sea surface temperature analyses (14 km resolution) were added to the product line. These new charts, covering the U.S. coastal waters, are being used by Weather Service Forecast Offices to serve the oceanographic data needs of fishermen and marine transportation companies.

Responsibility for SST chart production was transferred to the NOAA Ocean Products Center on January 1, 1986. To simplify chart production , 66 chartlets were replaced by 14 charts (1 global, 5 mesoscale, and 8 local-scale). All charts were made operational with digital archives and subscriptions available from the Satellite Data Services Division of NESDIS.

A new SST observation archive with additional information appended to each observation was made operational in support of the Tropical Ocean and Global Atmosphere (TOGA) Project of the World Climate Research Programme. Additional information stored with each observation include relevant satellite and sun angles as well as brightness temperatures or albedos for each of the AVHRR channels. This additional information will enable future reprocessing of all data with the most accurate multi-channel SST algorithm in support of climate applications.

A change was made in September 1986, in the way that AVHRR data is calibrated. Extensive testing and generation of bias corrections for multi-channel SST equations were required to implement a more sophisticated non-linearity correction for the 11 and 12 micrometer channels of the AVHRR. (B. Banks)

PART II. MAJOR RESEARCH AND DEVELOPMENT IN APPLICATIONS OF SATELLITE DATA

2.1 DMSP SATELLITE TEMPERATURE PROFILES

The implementation of a NESDIS operational product system to generate global temperature profiles from SSM/T (Special Sensor for Microwave Temperature Sensing) instrument data is scheduled for 1987. This instrument is flown on the U.S. Air Force's Defense Meteorological Satellite Program (DMSP) polar spacecraft. SSM/T data acquired from DMSP satellite are supplied to NESDIS under the Shared Processing agreement between NESDIS, the U.S. Air Force and the U.S. Navy.

Improvements made to the retrieval coefficient tuning procedure have eliminated a 3°K - 4°K cold bias at mid-tropospheric levels. Automation of the coefficient tuning system and continuing work on a limb correction procedure are currently being pursued.

Simulation studies of SSM/I (Special Sensor for Microwave Imaging) data have been on-going at NESDIS this year. Algorithms utilizing SSM/I data are being developed to increase sounding accuracy by improving the surface temperature, emissivity, and elevation corrections made to the lower tropospheric SSM/T channels. The SSM/I instrument is expected to be flown with the SSM/T instrument on DMSP satellites in 1987. (D. Gray)

2.2 NOAA-K,L,M POLAR TEMPERATURE/MOISTURE PROFILES

The NOAA-K spacecraft, scheduled for launch in 1992, will provide an improved atmospheric sounding capability through the use of improved instrumentation. The Advanced Microwave Sounding Unit (AMSU) will provide twenty (20) channels of information, relatively independent of cloud effects, on vertical atmospheric temperature and moisture distribution for each field of view (FOV), at a resolution of 50 km at nadir. The HIRS/3 will provide improved infrared measurements for better soundings in clear and partly cloudy areas.

Specifications for the sounding products to be operationally processed from the NOAA-K satellite series have been defined. In addition, initial specifications for science algorithms to be used for the processing of these products have been completed. Work has begun on the operational processing system design and simulated data generation for further science algorithm refinements. (D. Gray)

2.3 THE USE OF CLASSIFICATION PROCEDURES TO IMPROVE THE ACCURACY OF SATELLITE SOUNDINGS OF TEMPERATURE AND MOISTURE

Soundings produced by the National Evironmental Satellite, Data, and Information Service (NESDIS) are generated using a regression procedure to convert from measured radiances to temperature and moisture profiles. The regression uses a limited form of classification by using a microwave channel to interpolate between coefficients for the latitude zone. Recent work at NESDIS using simulated data has indicated that improvement is possible with more advanced classification procedures.

To evaluate the approach on actual measurements, about 6000 satellite-radiosonde matches covering all seasons and all latitudes were collected and divided into dependent and independent data sets. Retrieval coefficients were generated for the entire dependent set and for classes determined by the observed radiance patterns.

Comparisons were made between the various regressions and the operational retrievals included in the data. Initial levels of improvement in the troposphere average 0.2 to 0.3K for the operational results with specific levels reaching 0.3K. Resulting rms differences from radiosondes are less than 2.0K except at the tropopause and the ground with a minimum of 1.5K near 600 mb. Additional improvements are expected as the initial classification procedure is refined. Since the satellite/radiosonde matches include errors due to time and space differences and radiosonde errors in addition to satellite errors, actual improvements in satellite retrieval accuracy exceed the improvements in rms difference from radiosondes. (L. McMillin)

2.4 WEATHER FORECASTING - SEVERE STORM STUDIES

This project is a grant to T. Fujita, Univ. of Chicago, to study the characteristics and behavior of severe convective storms combining data from conventional, satellite, and special sources. Storms producing tornadoes and microbursts are the main focus. Microbursts have been isolated as the cause of several aircraft and watercraft disasters. Results indicate that microbursts are small, descend abruptly with little warning from convective cells, and spread radially at and near the surface, creating sharp shears over short distances. Many if not most microbursts occur in very innocuous appearing clouds of small vertical and horizontal extent. This project provides knowledge and concepts useful in understanding certain severe storms that when combined with local observations could aid in anticipating immediate danger. NOAA applications are generally to improve understanding and forecasting of severe local storms, especially tornadoes and microbursts. (R. Anderson)

2.5 INTERNATIONAL SATELLITE CLOUD CLIMATOLOGY PROJECT (ISCCP)

The primary ISCCP scientific objective is to produce a global data set of infrared and visible radiances that are calibrated, normalized, and spatially averaged and sampled to contain basic information on the radiative properties of the atmosphere, from which cloud parameters can be derived. Three and a half years of data of the planned five year data set have been collected. Additionally, ISCCP intends to stimulate and coordinate basic research on techniques for inferring the physical properties of clouds from these data to apply the resulting algorithms to derive and validate a global cloud climatology for improving the parameterization of clouds in climate models, and to promote research using ISCCP data for improved understanding of the Earth's radiation budget (top of atmosphere and surface) and of the hydrological cycle. Six years of clear pixel radiances have been collected to be corrected for surface skin temperature. (Ohring, Thomasell)

2.6 THE COHMEX EXPERIMENT

The Cooperative Huntsville Meteorological Experiment (COHMEX) took place this summer in the Huntsville, Alabama area. The COHMEX experiment included studies of: (1) microbursts and severe thunderstorms in a moist environment, (2) downburst influence on aircraft performance, (3) mesoscale environments as they affect precipitating storm development and evolution, and (4) arc cloud lines in order to better understand thunderstorm outflow dynamics and how the outflow interacts with the local scale environment to influence deep convective storm development. Observational systems that supported these various programs included GOES VAS (Special Rapid Scan Data were taken in support of COHMEX), TIROS, multiple Doppler radars, special aircraft flights under sponsorship of NSF, FAA and NOAA (P-3), special mesoscale rawinsonde coverage, mesonet support as well as special TVA rain gauge and surface observation information.

COHMEX is the first experiment of this type to be carried out in the southeast United States since the Thunderstorm Project of the 1940's. Data gathered from the most advanced satellite and ground based observational systems will be examined for further insight into the mesoscale environment of thunderstorms.

2.7 A MULTI-YEAR CLIMATOLOGY OF CLOUD COVER FROM NIMBUS-7 SATELLITE DATA

Radiances from the eleven micrometer channel of the temperature humidity infrared radiometer (THIR) and the 0.38 micrometer channel of the total ozone mapping spectrometer (TOMS) are used to derive cloud cover information, globally, from the Nimbus-7 satellite. Fractional coverage of fixed areas on the Earth, namely $(160\ km)^2$, by low, middle and high altitude clouds, their radiance at 11 micrometers and the spatial and temporal variances of these quantities have been computed daily and monthly at local noon and midnight from April 1, 1979 to March 31, 1985. This data set is archived at NASA/GSFC, NSSDC, Greenbelt, MD 20771. Applications are: to understand the variability of cloud cover and how this variability affects or is related to the Earth's radiation

balance, atmospheric circulation and climate anomalies, and to validate and improve long range weather prediction and climate prediction models.

Other possible applications are: to aid industries dependent on solar energy in deciding which locations may have least cloud cover; to relate cloud cover to precipitation for agriculture industry; to provide data on available solar energy for agriculture; to locate desirable locations for development by the building industry. (L. Stowe)

2.8 NOAA SATELLITE OBSERVATIONS OF AEROSOL OPTICAL THICKNESS OVER OCEANS

Measurements of the radiance of reflected solar radiation over cloudless ocean areas are entered into a theoretically derived look-up table procedure which, for the particular solar incidence angle and satellite instrument viewing angle, returns an estimate of the aerosol particle optical thickness at a wavelength of 500 nanometers.

Applications at NOAA are to monitor changes in aerosol content of the atmosphere which might lead to change in the Earth's climate; study how these changes affect the Earth's radiation balance; and correct operational products, such as sea surface temperature, for the affects of aerosol contamination.

NOAA is also developing remote sensing methods to estimate aerosol particle optical thickness, size distribution and index of refraction for a vertical column of the atmosphere over cloud-free ocean surfaces using measurements of the intensity of reflected solar radiation from a modified version of the AVHRR instrument for the NOAA-K,L,M satellites.

Other possible applications are: track the course of volcanic eruption clouds hazardous to aviation; track the course of polluted air outbreaks; identify arid land areas from dust plumes generated by winds. (L. Stowe)

A new product, global aerosol optical thickness, developed by the NESDIS Office of Research and Applications is being tested. Once this product becomes operational, it can be used to correct multi-channel SST for the effects of volcanic aerosols in the stratosphere such as those which were generated by the El Chichon volcano in 1982 (which caused up to $4^{o}C$ errors in satellite SST). (B. Banks)

2.9 SATELLITE EARTH RADIATION BUDGET STUDIES

Data from the Nimbus-7 Earth Radiation Budget (ERB) experiment have been analyzed and angular reflection and emission models have been developed for a variety of surfaces (cloud, land, water, snow, ice). Also, models that describe the dependency of albedo on solar zenith angle for each surface have been developed. These models will be used in the calculation of planetary radiation budget from TIROS-N AVHRR data and from the NASA Earth Radiation Budget Experiment (ERBE).

The planetary radiation budget has been routinely calculated from NOAA operational spacecraft beginning with data from June 1984. The albedo and emitted flux are calculated from visible and infrared observations from the AVHRR. Comparisons with other estimates of the planetary radiation budget have been made, and, as a result, new and improved methods for the calculation of the planetary radiation budget from the narrow spectral data have been developed. Comparison of AVHRR derived radiation budget will be validated by comparison to data from the Earth Radiation Budget Experiment currently in progress. (A. Gruber)

A two-spacecraft radiation budget operation was conducted for the first time in 1986 using NOAA-8 and NOAA-9 data. A test was conducted, calculating new cloud histograms at the same time that radiation budget parameters are calculated. The Climate Analysis Center of NOAA will use the cloud histograms for tropical precipitation estimates. Preparations were made to generate cloud histograms and radiation budget from both NOAA-9 and NOAA-10 early in 1987.

2.10 MESOSCALE CONVECTIVE CLOUD CLIMATOLOGIES

Computer averaging of GOES digital satellite data for repetitive times and geographic areas during the summer months of 1986 has generated a satellite "climatology" data set for use in studying regional cloud formation and distribution patterns. Visible and infrared data were used. These averages will serve as a valuable tool for mesoscale and data sparse area forecasting. (J. Weaver)

2.11 NOAA/UNIVERSITY OF MARYLAND COOPERATIVE INSTITUTE FOR CLIMATE STUDIES

NESDIS participation in the CICS provides support for the following:

1) Analysis of radiation budget data for validating climate models

2) Development of radiative-transfer models for the study of satellite derived climate parameters

3) Study of surface radiation budget derived from satellite data

NOAA applications are to further the development of climate parameter extraction from satellite radiances and understanding of the climate system. (A. Gruber)

2.12 FGGE-MCSSTs RECALCULATED FORM TIROS-N AVHRR DATA

During the 1979 FGGE year sea surface temperature (SSTs) from TIROS-N were still being calculated from one infrared window channel using techniques developed during the '70s (GOSSTCOMP products). Although the AVHRR on TIROS-N was only a 4-channel instrument and the 3.7um channel suffered from substantial electrical interference ("noise"), NESDIS has been successful in eliminating much of this noise so that multi-channel SSTs (MCSSTs) can be derived. Preliminary comparisons with FGGE buoy data reveal that GOSSTCOMP accuracy in 1979 was in the vicinity of $\pm 1.0°C$, whereas the revised MCSST data for 1979 is in the $\pm 0.75°C$ range. (A. E. Strong)

2.13 CZCS STUDIES IN HIGH LATITUDES

Data collected from the Coastal Zone Color Scanner (CZCS) on the Nimbus satellite from the south and western areas off Iceland between April and June 1981 showed the evolution of the spring bloom originating near shore and progressing seaward. The local wind field and timing of spring flooding appear to be the predominant influence on the phytoplankton growth, based on this CZCS data. Similar work is being done in the Bering Sea. (D. Clark)

2.14 EASTERN EQUATORIAL PACIFIC SEA SURFACE TEMPERATURES (SST)

Five years (1982-1986) of multichannel very high resolution radiometric data from the NOAA polar orbiting satellites have been accumulated at weekly intervals, and 50 km resolution, on an interactive computer system. This time lapse view depicts the annual and interannual variations of the SST associated with the 1982-83 El Nino and Southern Oscillation. (R. Legeckis)

2.15 SURFACE HEATING

Studies of GOES observations of surface heating showed a definite relationship between monthly average precipitation and the average monthly surface heating at a given site. Larger surface heating between 0900 and 1200 local time are associated with low precipitation. There is also an approximately linear relationship between surface heating between 0900 and 1200 local time and air heating for the same period. (D. Tarpley)

2.16 SNOW AND CLOUD DISCRIMINATION

The next generation of polar orbiting satellites (first launch scheduled for 1992) will carry a near-infrared (1.8 um) channel permitting the separation of clouds from snow. 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.

2.17 SOLAR RADIATION FROM GOES

Hourly and daily estimates of solar radiation incident at the surface from GOES data have been produced and archived at NESDIS since June 1982. The coverage for this experimental product includes the U.S. and agriculturally important areas of Mexico and South America. The insolation algorithm relates measured brightness in the visible band to hourly insolation. Hourly estimates are summed to give a daily total. The daily insolation values have errors of 10-15%. (D. Tarpley)

2.18 PRECIPITATION

Work continues in refinement of precipitation techniques. Isolating signatures of heavy precipitation cloudiness, incorporation of rain burst, and storm speed factors, relationship of stability indices and its change during an event are some of the parameters being examined and tested for convective and winter storm situations. (R. Scofield)

2.19 RAPIDLY DEEPENING WINTER STORMS

Case studies are being assembled and upper level wind sets are being developed for oceanic storms using interactive processing techniques. Preliminary results show that rapidly intensifying storms have a very strong upper level divergence of the order of 10^{-3} sec^{-1}. (G. Ellrod)

2.20 TURBULENCE

A study of atmospheric turbulence has shown that, in addition to the signatures in visible and infrared satellite imagery, the 6.7um water vapor channel of the GOES satellites also can provide an indicator of turbulence. It was found after examining 100 cases in which there was an increase in the 6.7um channel brightness temperatures (darker gray scale) as a function of time, that over 80% of these cases had reports of moderate to severe turbulence with them. Thus, the water vapor channel can also be useful in diagnosing areas of probable turbulence for commercial and military jets. Current efforts are to develop a decision-tree technique for forecasting turbulence. (G. Ellrod)

2.21 DESIGN SPECIFICATIONS FOR THE NOAA-K SOUNDER PROCESSING SYSTEM

A preliminary design specification for the NOAA-K sounder processing system has been completed. These specifications are for processing data from the AMSU-A and AMSU-B microwave sounders and the HIRS-3 infrared sounder, which will be operational in the early 1990's. Products that are planned to be processed operationally include vertical profiles of temperature and water vapor, precipitation, cloud parameters, sea surface temperature, ice and snow cover, daily and monthly mean radiation budgets, ozone, and vegetation indices. (H. Fleming)

2.22 STRATOSPHERIC CONSTITUENTS

Ozone determinations from operational satellite observations are made from two instrument systems: the Tiros Operational Vertical Sounder (TOVS) and the Solar Backscatter Ultraviolet Radiometer (SBUC/2).

A data set of total ozone amount from the TOVS observations covering the period May 1979 - May 1986 has been assembled. These data were derived from determinations of total ozone amount by a regression procedure using TOVS infrared radiances and total ozone determinations from the spectrophotometer network. The TOVS data are being compared with contemporary total ozone amount determined from SBUV observations on Nimbus-7. There is general agreement between the two sets of observations on zonal scales. These comparisons will continue as longer data sets from both instruments become available.

Ozone determinations, both total ozone amount and vertical distributions, are also to be made available from the SBUV/2. Launched late in 1984, the instrument system underwent extensive in-orbit testing and evaluation. Based on these, the ground data-processing system algorithms required modification to accommodate the new engineering information. This has been done and retrospective processing on archived satellite data back to March 1985 will begin in May 1987 with the processing to be completed by June 1, 1987. After that, the processing system will be operational and operate on a daily schedule. In the interim, an extensive set of ground-based observations of ozone have been collected and will be used to validate the satellite measurements.

2.23 WATER VAPOR WINDS

Winds derived from water vapor tracers observed in a sequence of images of the 6.7 micrometer channel on the VISSR Atmospheric Sounder (VAS) continue to be of strong interest because of the completeness of coverage. They have, furthermore, been of special interest to the World Climate Research Program as a source of mid-level winds not available from traditional cloud tracing techniques. However, research into the height assignment for the water vapor tracers indicates that they typically represent the flow above 350 mb which is considerably higher than previously believed. Research is being conducted with the 7.2 micrometer channel of VAS, and additional moisture channels have been specified for GOES-NEXT to seek motions which more truly represent midlevels. (Hayden)

Part III. TECHNIQUES DEVELOPMENT AND APPLICATIONS OF SATELLITE DERIVED PRODUCTS AND SERVICES

3.1 VAS DATA UTILIZATION CENTER (VDUC)

The VAS Data Utilization Center was installed in 1986. The system consists of an IBM 4381 computer and 9 remote workstations (user terminals). This system is planned to process VAS geostationary imagery and data beginning in mid-1987. (G.Legg)

3.2 PERSONAL COMPUTER WORKSTATION FOR SATELLITE METEOROLOGY

An assessment of the feasibility of using a low-cost personal computer to provide operational forecasting support of meteorological satellite data products was performed during the Field Operations Phase of NOAA's PRE-STORM Experiment. The personal computer workstation combined readily-available hardware components with applications software developed jointly by two of NOAA's cooperative research institutes at Colorado State University and University of Wisconsin-Madison. During the two-month Field Project, two workstations supplied satellite-derived products to satellite meteorologists in the PRE-STORM Operationas Center to assist the program directors in day-to-day mission planning and in research aircraft flight directing. Digital visible and infrared imagery were acquired in near real-time from a remote mainframe computer and animated on the workstation. Satellite atmospheric sounder profiles were remotely accessed and processed into numerous meteorological parameters to assist in mesoscale forecasting.

To summarize the assessment of the personal computer workstation in an operational environment: (1) the hardware and software were quite reliable in day-to-day operation; (2) the menu approach for the user interface presented a smooth flow to the analyst with a minimum of user training; (3) communication rates were marginal even with the aid of data compression; (4) satellite imagery displays were adequate for quick assessment of the meteorological situation,

with the ability to perform mesoscale forecasting improved by an animation. The workstation adequately provided products to the meteorologist in a timely fashion to aid in forecasting. The personal computer workstation is a cost effective method for supplementing specialized data sources into the data streams of a forecaster or of a research meteorologist. Such systems will be even more effective as microcomputer technology becomes more powerful and less expensive.

PART IV. CURRENT SATELLITE SYSTEMS

4.1 GEOSTATIONARY SATELLITE SYSTEM

The U.S. Geostationary Operational Environmental Satellite (GOES) system consists of two satellites, GOES-West located at 135° W longitude and GOES-East located at 75° W longitude. The GOES-5 (GOES-East) VISSR imager failed in 1984. Since then, GOES-6 has provided operational imaging and sounding services from a central location at 108° W. GOES-7 was launched on February 26, 1987, and will be utilized as GOES-East. It will become operational in March 1987. GOES-6 will be moved to the GOES-West position in April 1987. The normal two GOES system will then be re-established after three years of single GOES operations. Other partially functional GOES spacecraft including GOES-2,3,4 and 5 do not provide imagery or sounding data but support data collection services, WEFAX, and other data communication functions. GOES-4 is positioned at 44° W to support the data collection for ESA.

The U.S. has contracted for the next generation geostationary satellite system called GOES-I,J,K,L, and M. The launch of the first of this series, GOES-I, is planned for the late 1989. This new series of GOES spacecraft will provide geostationary services into the late 1990's.

4.2 POLAR-ORBITING SATELLITE SYSTEM

The U.S. polar-orbiting satellite (POES) system is the advanced TIROS-N/NOAA series and currently consists of two operational satellites providing global coverage at different times of the day. NOAA-9 is in an afternoon orbit (1504 local Equator-crossing time ascending), and (0733 local Equator-crossing descending). These satellites are in sun-synchronous orbits at altitudes of 852 and 814 km, respectively. The Microwave Sounding Unit (MSU) of NOAA-9 failed on March 7, 1987, and therefore no vertical sounding retrievals are being obtained from NOAA-9.

Four additional NOAA spacecraft are either completed or under construction. These spacecraft, NOAA-H,D,I, and J, are planned to be launched as required to maintain polar system continuity. NOAA-H is planned to be launched in late summer 1987. The last spacecraft of the present series, NOAA-J, is expected to be launched around 1991. A continuation of the polar-orbiting environmental satellite services is planned for the 1990's with NOAA-K,L and M. The first of this series, NOAA-K, is planned to be launched in 1992 and NOAA-M is expected to be launched around 1995.

PART V. FUTURE SYSTEMS

5.1 NOAA-K,L,M

Activities necessary for the implementation of the next generation of polar-orbiting environmental satellites (NOAA-K,L,M) are well underway in preparation for a 1992 launch of NOAA-K. The addition of the Advanced Microwave Sounding Unit (AMSU), and the addition of a 1.6 micrometer channel on the AVHRR will make possible many new and improved products. The operational sounding system will be completely rewritten to synergistically use data from the AMSU, the HIRS/2-I and the AVHRR/3 instruments. Major revisions will also be made to the image processing system, the radiation budget system, and the SST system. The NOAA-K,L, M Implementation Plan was released in February 1986. (D. Bowman)

5.2 GOES I-M

The GOES I-M project has the goal of providing an operational system for the next generation of GOES spacecraft (first launch: October 1989). The differences between this new generation and the current system are substantial: a three-axis stabilized spacecraft vs. the current spin-stabilized; and separate and independent imaging and sounding instruments vs. the current combined instrument.

GOES I-M project activities have consisted of reviews of the developing designs of the instruments and ground systems and preliminary analyses of the impacts of the spacecraft changes on current ground processing systems. The project organization was formalized on September 9, 1986, and a project plan is being developed. Near real-time mapped GOES images of the United States will be one of the significant new products from GOES I-M. (G.Hughes,M. Shellman)

PART VI. VALIDATION AND VERIFICATION OF PRODUCTS USED IN OPERATIONS

6.1 GLOBAL FIRE PRODUCT

An experimental product has been created that shows global fire activity. The product is based on the AVHRR 3.8 micrometer channel onboard the NOAA polar-orbiting satellites. This channel is sensitive to high temperature targets such as fires. The experimental product depicts the fire activity as white "hot" spots displayed on polar-stereographic projections of the northern and southern hemisphere. New processing algorithms have been developed and will be applied to data collection over the summer of 1986. (M. Matson)

6.2 IMPROVED MOISTURE BOGUS FOR ANALYSIS

Various methods and accuracies of satellite moisture profile derivations are discussed in a new NOAA Technical Report (NESDIS 24). The National Weather Service is presently evaluating procedures for moisture assimilation, including satellite-based observations in the various numerical models.

6.3 CALIBRATION OF VISIBLE SENSOR

Concurrent aircraft and satellite data are being analyzed to develop calibration coefficients for polar and geostationary visible channel data. Increasing use of the visible data for quantitative analysis (e.g. vegetation index) requires calibration of this data to ensure accurate analysis. The White Sands Monument, New Mexico has been used as the target of study. Final results are expected in 1987.

6.4 AVHRR AND SST MONITORING AND VERIFICATION

A study of interactive techniques of SST and ocean-feature product production was conducted and techniques were developed for mapping and display of full-resolution AVHRR data. These techniques will be useful for SST multi-channel algorithm assessment, monitoring of the accuracy of AVHHR earth locations, and investigations of AVHRR raw data calibration and instrument noise problems.

6.5 GOES DATA COLLECTION SYSTEM (DCS)

The DCS has 5813 Data Collection Platforms (DCP's) at which 4400 are currently active. These DCP's provide ground truth information concerning various hydromet parameters such as; water levels, precipitation, air temperature, wind speed and direction, incoming solar radiation, snow depth, snow water equivalent, barometer pressure and etc. These data are transmitted at fixed time intervals when conditions are normal, and immediately when any abnormal conditions are detected by the DCP's sensors. These abnormal conditions are pre-determined by the user and are based upon the users applications and need to know responsibilities.

The U.S. National Weather Service (River Forecast Centers) and other major Federal users such as; Bureau of Reclamation, U.S. Geological Survey, Water Resources Division, Bureau of Land Management, U.S. Army Corps of Engineers, and the National Park Service use these data as inputs to their water regulations and management programs.

The existing GOES-DCS ground system is scheduled to be replaced in the late 1988 or early 1989 time period. The replacement ground system will be capable of utilizing the full 200 channel DCS capacity of the GOES spacecraft. It will also be capable of supporting DCP's with the transmission rates of 1200 band, an improved wide band random reporting mode of operation, and the re-transmission of DCP data through a domestic satellite.

The collection of ground truth information from remote areas on a fixed and emergency basis has become a major source of data input in the operational programs of many Federal users concerned with water management, flood forecasting and reservoir control.

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VENEZUELA

PART I

In the current year, the infra-red and visible satellite data, and satellite data in numerical form from the United States WEFAX service have been a valuable aid in conventional tropical analysis and prediction. These data are urgently needed owing to the scarce coverage or total absence of meteorological observations in the tropical Atlantic and equatorial South America.

PART II - MAIN RESEARCH AND DEVELOPMENT

Not applicable.

PART III - TECHNIQUES FOR THE APPLICATION OF SATELLITE DATA

(a) Satellite images are interpreted in the conventional way and the results are used in the siting and monitoring of tropical weather systems, including the cloud type and quantity, the location of frontal systems, watercourses, tropical cyclones and easterly waves. Analyses are carried out at 12.00, 18.00 and 20.00 UTC.

(b) The following quantitative data are normally used in conventional tropical analysis:

- Vertical sounding data from NOAA polar-orbiting satellites, received via the GTS in the SATOB code.

- Displacement vectors of clouds and GOES geostationary satellites, received in SMT in SATOB code.

(c) The maps analysed and forecast by the United States WEFAX service are frequently used for comparison and orientation in the analyses of daily forecasting and in aeronautical meteorology.

PART IV - RECEPTION SYSTEMS

Main Components

See original.

PARTS V, VI, VII

Not applicable.

YUGOSLAVIA

National Hydrometeorological Agency - Republic of Serbia

PART I A BRIEF SUMMARY OF THE MAJOR HIGHLIGHTS OF RESEARCH APPLICATIONS AND OPERATIONAL CHANGES

A receiving APT/WEFAX - type system has been installed in National Hydrometeorological Agency of Serbia - Belgrade, in 1986.

Applications of VIS and IR (and WV) imagery received from METEOSAT (and occasionally from polar - orbiters) are concentrated mainly on synoptic analysis and forecasting.

PART II N/A

PART III A DESCRIPTION OF TECHNIQUES DEVELOPMENT AND APPLICATIONS OF SATELLITE DATA, DERIVED PRODUCTS AND SERVICES

In the Forecast Division of the National Hydrometeorological Agency processed METEOSAT images are regularly received; the APT pictures from polar - orbiting satellites of NOAA and METEOR-series are used occasionally.

The everyday use of VIS and IR images contributes to the improvement of the analysis of current weather situations and short-range forecasts, as well as severe weather warnings. This include mainly the detection of major weather systems like mid-latitude depressions with associated frontal systems, relatively small-scale features like squall-lines and thunderstorms, then fog and jet-streams and the rough estimate of their intensity, development and movement.

The satellite pictures are also used in weather presentation on National Television.

PART IV A BRIEF DESCRIPTION OF THE SYSTEM FOR SATELLITE APPLICATIONS IN OPERATIONAL USE IN 1986.

In National Hydrometeorological Agency in Belgrade a simple home-made receiving system is used for operational reception of meteorological satellite imagery. This is a station of APT/WEFAX-type for the reception of low-resolution analogue data which consists of 1.8 m diameter parabolic antenna, down-convertor (1.7 GHz/137 MHz), VHF dipole antenna, VHF preamplifier, VHF receiver, color monitor as an image display device and tape recorder to store images.

PART V to VII N/A