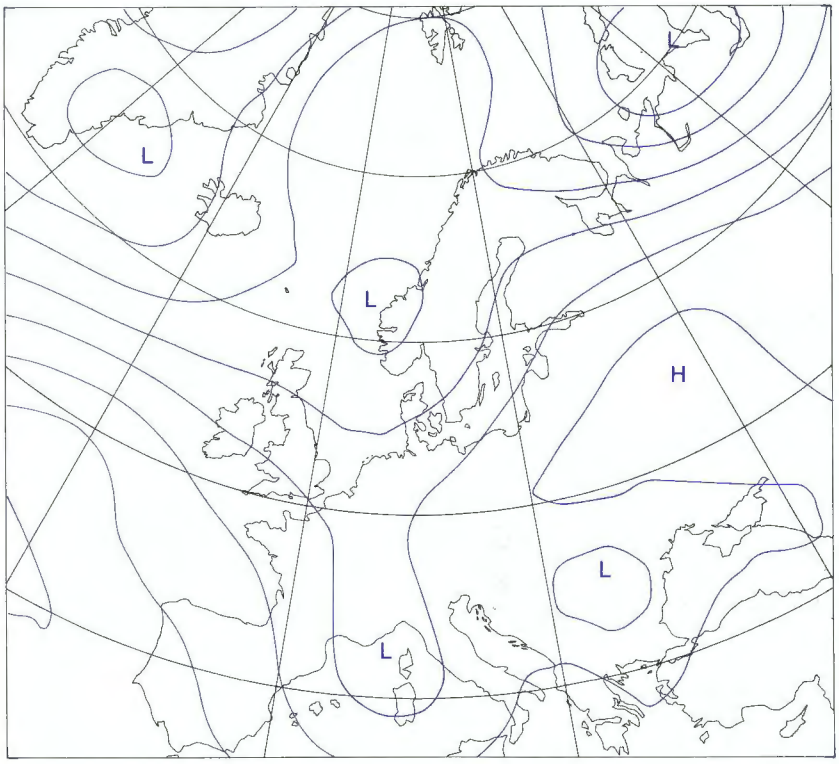
Annual Report 1977



European Centre for Medium Range Weather Forecasts

Contents

Prof. Lauri Vuorela, President of the Council.

Foreword

The year of 1977 has been a period of intensive activity and progress for the European Centre for Medium Range Weather Forecasts. Italy has ratified the Convention. Various experiments and tests towards development of the Centre's operational forecasting model have been carried out successfully. Decisions made at the fourth and fifth sessions of the Council regarding selection of the main and front-end computer systems have fulfilled the principal requirements of ECMWF's permanent computer facilities and made it possible to proceed with measures for an interim installation. The number of staff of the Member States is steadily increasing. Educational activity has been practised in form of a scientific seminar and steps have been taken to ensure the Centre's contribution to the First Garp Global Experiment. There is good reason to state that the Director of the Centre and his staff have done excellent work in all sectors of the Centre's functions.

The contractor appointed by the United Kingdom government has made considerable progress in building the permanent headquarters at Shinfield Park, Reading.

On the whole, the achievements of the Centre's second year can be viewed with satisfaction and confidence and the outlook for the future development seems prosperous.

It is hence my pleasant duty, on behalf of the European Centre, to express to the Government of the United Kingdom and to the Director of the Centre and its staff my sincere thanks and best compliments. I also would like to extend words of appreciation to my colleagues in the Council and its Committees for their excellent contribution.

Lauri A. Vuorela

Introduction

The European Centre for Medium-Range Weather Forecasts came significantly closer to becoming a fully developed institution during 1977. This year was the second full year since the ratification of the Convention in November 1975.

Computers

A very significant event during 1977 was the decision by the Council that the main part of the Centre's computer system should be a CRAY–1 computer. Equally important was the approval by the Council that an interim CRAY computer could be installed in temporary quarters awaiting the completion of the permanent headquarters building at Shinfield Park presently scheduled for the last quarter of 1978. The contract with the company was signed in June 1977 and the CRAY computer was installed at the Rutherford Laboratory in November 1977.

Signature of the ECMWF/CRAY contract in Minneapolis – Mr. Seymour Cray, Managing Director, Cray Research Incorp., Dr. A.C. Wiin-Nielsen, Director, ECMWF

The front-end for the CRAY–1 was also selected during 1977. The final decision by the Council was that the CDC CYBER 175 was the most suitable. A contract for such a front-end computer was signed in November 1977 with a scheduled delivery time around New Year 1978 at the same location as the CRAY–1 computer.

Signature of the ECMWF/CDC Contract at Fitzwilliam House, Bracknell – Mr. J.H. Ward, Managing Director, Control Data Ltd., Dr. A.C. Wiin-Nielsen, Director, ECMWF

Telecommunications and Graphics

The missing part of the planned three tier computing system was then the telecommunications and graphics sub-systems. The chosen contractor was Service in Informatics and Analysis Ltd. (UK), a subsidiary of a French company, with A/S Regnecentralen (Denmark) as a sub-contractor, for the telecommunication system, while the graphics system will be developed step by step. During the major part of 1977 the Centre continued to use the CDC 6600 computer at John Scott House, Bracknell, supplemented by the IBM 195 computer at the UK Meteorological Office.

Another significant decision during 1977 was the adoption by the Council of the recommendations prepared by the Advisory Committee on Communications between the Centre and the Member States. The major decision was that a telecommunications network consisting of medium speed lines should be established between the Centre and the Member States. A timetable for the connection of the various national meteorological services to the Centre was adopted. Low speed lines will be used initially in some cases, but by 1984 the complete medium speed network should be working.

Modelling

Parallel to these technical developments, the Centre has continued to develop the analysis and forecasting system to be used when operational forecasting starts in 1979. The details of the research are described in the report of the Research Department and in a number of technical and internal reports made available to the Member States. During the latter part of 1977 it was necessary to use a substantial part of the Centre's manpower to prepare for the use of the new computer system. Based upon the various tests of the analysis and forecasting system carried out during 1977, there is good reason to believe that the Centre will be ready to begin operational work early in 1979.

GARP Activities

Since the major objectives of the First GARP Global Experiment (FGGE) of the Global Atmospheric Research Programme (GARP), sponsored jointly by the World Meteorological Organization (WMO) and the International Council of Scientific Unions (ICSU), are very close to the objective of the Centre to produce 4-10 day forecasts, it was decided earlier that the Centre should produce a set of global analyses during the entire FGGE Operational Year (December 1978 – December 1979). During 1977, the Centre has submitted its plans for the analysis scheme to the GARP Review Board, and the Centre has, together with the Geophysical Fluid Dynamics Laboratory in Princeton, USA, been designated for the production of Level III-b data. The Centre has participated in the international planning of all GARP activities. The Director was appointed a member of the Joint Organizing Committee for GARP during 1977, and the Deputy Director of Research replaced the Director as Chairman of the Working Group for Numerical Experimentation under the Joint Organizing Committee.

During 1977, the Administration Department was to a high degree involved in the many preparations for the occupation of the new Headquarters building at Shinfield Park. Numerous invitations to tender were prepared, and the evaluations of the submitted bids occupied much time and manpower. Most of this work is carried out by the General Services and Supplies Section which has experienced a very heavy workload during the year. Another section with a significant workload is the Personnel Section due to the steadily increasing staff at the Centre. During the year, the Council approved a re-organization of the Operations and Research Departments creating two divisions

in each department. The two in the Operations Department are the Computer Division and the Meteorological Division, while the Research Department is divided into the Model and Data Divisions. These changes will be implemented during 1978.

Prof. M. Petrossiants and Dr. V. Sadakov from the USSR – visit to ECMWF in October, 1977.

The Centre has continued its co-operation in scientific and technical matters with institutions outside the Member States, engaged in development and research closely related to its own activities. In October 1977, a delegation from the Hydrometeorological Service of the USSR visited the Centre.

Research Department

Structure

The Research Department is now divided into two divisions, a Data Division and a Model Division. The Data Division consists of three sections, namely Diagnostics, Data Assimilation and FGGE, with the following responsibilities :

Responsibilities

Diagnostics – development of diagnostic and verification systems for numerical models; development of the research data bank.

Data Assimilation – development of the basic formulation of methods of objective analysis and initialization for the Centre's prediction models; carrying out studies of observing system to assess the meteorological observing network requirements.

FGGE – planning, development and production of the FGGE Level III-b data set.

The Model Division, which is responsible for the formulation and construction of numerical models of the atmosphere, consists of two closely linked sections, Numerical Aspects and Physical Aspects. These two sections have the following main tasks :

Numerical Aspects – development of the basic dynamical and numerical formulation of the Centre's forecasting models.

Physical Aspects – development of parameterization schemes to account for sub-grid scale processes in numerical models.

Introduction

The scientific work of the Research Department in 1977 has been concentrated on the development of the analysis and forecasting system to be used by the Centre when it starts operational forecasting in 1979.

The major part of the development of the prediction model and the global analysis and initialization system has been completed in 1977. The prediction model and the analysis system have been tested using real data on the CRAY–1 computer.

The computer speed obtained so far on the CRAY–1 computer is sufficient to carry out an integration using a forecasting model with a horizontal resolution of 150 km and 15 vertical levels within the operationally assigned time, i.e. about 10 hours. At present, the code for the prediction model executes 30-40 times faster on the CRAY–1 than on the CDC 6600 computer. An evaluation of the prediction experiments carried out so far indicates predictability better than persistence for the largest scales of atmospheric motion throughout the whole 10-day period.

Development of the Centre's Forecasting System

The analysis system which the Centre has developed is based upon optimum interpolation. This methodology, which so far has been implemented operationally at only a few weather services, has been

found to be very suitable for the Centre's need. The form of this optimum interpolation method is 3-dimensional, and surface pressure, horizontal wind and geopotential are analyzed simultaneously. In a global analysis system it is necessary to rely heavily on satellite observations (temperature soundings and wind from drifting clouds) as well as on other non-synoptic information in regions where synoptic data is sparse.

Global analyses have been carried out using global data collected during special so-called Data Systems Tests. These DST data have been collected by the National Space Administration, USA, and cover two periods of two months each, August-September 1975 and February-March 1976. The quality and coverage in these data sets are similar to those expected operationally when the Centre becomes fully developed. In addition to surface and radiosonde observations, the DST data set includes non-conventional observations such as reports from aircraft, satellite temperature soundings and wind observations obtained from satellite cloud observations. It has been found during these experiments that satellite information has a beneficial effect on the analyses for large ocean areas of the Northern Hemisphere and a substantial influence on the analysis for the Southern Hemisphere. The analyses produced agree closely with analyses produced operationally at the World Meteorological Centre in Washington, D.C., USA in the Northern Hemisphere, but agree better still with analyses from Melbourne, Australia in the Southern Hemisphere. A new technique for initializing the analyses for the prediction model has been developed and tested; in tests it improved prediction and is very efficient in controlling gravity wave oscillations which are normally substantial during the first days of the integration.

The development of the Centre's first forecasting model has been almost completed during the year. The programming has been carried out to facilitate the exploration of different versions of the model. The model, intended as the first operational model, will be integrated for the whole globe and will have 15 vertical levels between the surface and 25 km. The mesh size will be around 150 km ensuring that weather disturbance with a scale larger than about 1000 km will be treated with satisfactory accuracy.

It has been a major concern to incorporate the description of the physical processes in the atmosphere as realistically as possible in the models. Radiation processes are important in the prediction of up to 10 days and consequently an important project has been to describe the interaction between the radiation processes and clouds as well as the effect of water vapour, carbon dioxide and ozone on radiation processes. The exchanges of heat, momentum and humidity between the atmosphere and the surface are also very important; in particular, their dependence on the static stability of the boundary layer and the surface conditions has been taken into consideration. Very good simulations have been obtained in describing the daily variation and physics of the boundary layer; the results are in good agreement with observations.

Substantial efforts have been made to develop a system to diagnose and verify the predictions. A system has been established whereby the performance of the model is investigated for different scales of motion. The diagnosis also shows how well the model can describe the important energetic processes in the atmosphere. A research library of climatological data is being established for use within the Centre.

Scientific activity has been high and seven Technical Reports and fifteen Internal Reports have been published during the year. These reports have been sent to the Members States and also to other scientific groups engaged in research in weather prediction.

FGGE Activities (First GARP Global Experiment)

During a meeting of the FGGE Review Board in October, the Centre was officially designated as a Level III-b data producer for the global experiment. The Centre and the Geophysical Fluid Dynamics Laboratory in Princeton, USA will be the two designated Level III-b data producers for the global experiments. The Level III-b data set will include global analyses of the basic meteorological parameters for the standard levels between surface and 10 mb. The data set will be produced and archived twice daily for the entire FGGE Operational Year (December 1978 - December 1979).

Scientific Co-operation with Member States

Active co-operation has taken place between the Centre and the Member States. Members of the Research Staff have visited research organizations in the Member States; scientists from the Spanish Meteorological Institute and the Swedish Meteorological and Hydrological Institute have visited the Centre in order to investigate whether a limited area version of the Centre's model can be used for short-range forecasting within their own services.

A scientist from Holland spent one month at the Centre to work with the analysis system and several other scientists from the Member States have spent short study visits at the Centre.

A special workshop was held from 2nd to 4th November 1977 at the Centre on the use of empirical orthogonal functions in solving meteorological problems. The efficiency of these functions for data checking and data reduction was demonstrated. Proceedings from the workshop will be published.

Operations Department

Structure

The Operations Department is divided into two parts – one concerned with computing and other technical facilities, the other with the operational meteorological problems. These are now formally known as the Computer Division and the Meteorology Division respectively. The Computer Division comprises four sections, namely Computer Operations, Operating Systems. Telecommunications and Graphics, and User Support, with the following basic tasks and responsibilities :

Responsibilities

Computer Operations	–	day to day operation of the computer system.
Operating Systems	–	implementation, maintenance, development and support of the basic software (operating systems, compilers, utilities), of the computer complex.
Telecommunications and Graphics	–	all aspects of the communications facilities, the internal terminal network and the telecommunications network linking the Centre and the Member States, design and phased implementation of graphics system including software, plotters, graphical terminals, microfilm plotters.
User Support	–	assisting users in all aspects of use of the Centre's computing facilities and in programme development, maintenance of programme libraries, file management and documentation (including preparation of the Centre's recently introduced Computer Newsletter).

The Meteorology Division is divided into two sections – Meteorological Applications and Meteorological Operations. These sections have the following basic tasks and responsibilities :

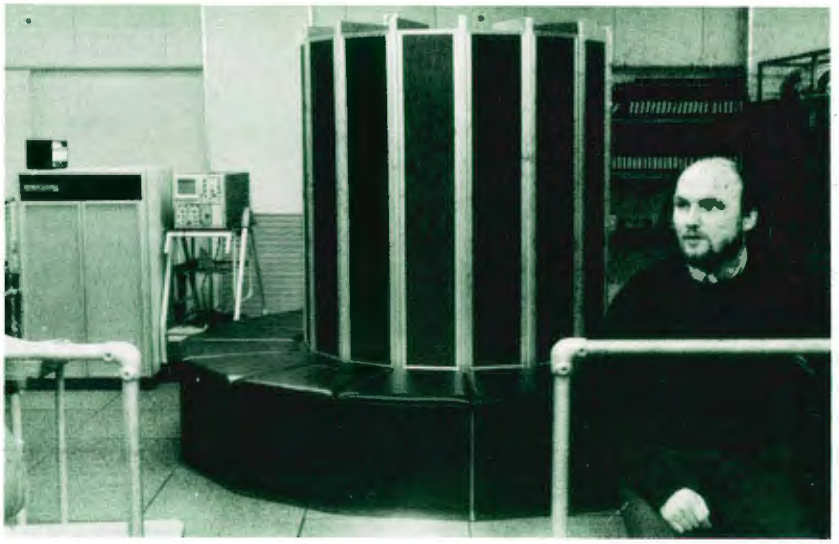
Meteorological Applications	–	programming and implementation of the full meteorological operational cycle required to sustain the daily production of medium-range forecasts in real time.
Meteorological Operations	–	monitoring and evaluation of the operational cycle from a meteorological point of view, including checks of consistency of input data and forecast results.

Overall, the work of the Operations Department in 1977 has been dominated by the need to acquire and implement a computer system and develop a meteorological operational suite which together will be able to support operational medium-range weather forecasting in 1979. There have been three main aspects to the work – the acquisition and development of the computing and other technical facilities, the support of interim computing arrangements to enable trials of the models and analysis scheme to be carried out by the Research

Department, and finally the implementation of operational forecasting itself.

Acquisition of New Computing Facilities

At the heart of the Centre's operation in the new Headquarters building at Shinfield Park will be a powerful computer complex. To carry out the role of operational medium-range weather forecasting, a three tier computing system is planned, consisting of a powerful "number cruncher", front-ended by a more conventional computer with all the normal facilities offered by modern operating systems needed to control the running of the operational forecast and associated data handling tasks; this front-end system is in turn front-ended by smaller computers to control the communications with Member States and to control the graphical output devices. The whole of the Operations Department has been deeply involved throughout the whole process of evaluation and decision making leading to the acquisition of the appropriate computer facilities for the various levels.



CRAY–1 interim machine now installed at the Rutherford Laboratory.

Computer System

As recorded in the Annual Report for 1976, the Invitation to Tender for a Computer System for ECMWF was issued in July 1976. By the middle of December 1976, following careful and intensive examination of the proposals received, recommendations concerning the selection of computers for installation at the new Headquarters were made by the internal Centre Tender Evaluation Board. These recommendations were then considered firstly by the Scientific Advisory Committee and secondly by the Advisory Committee on the acquisition of the Computer System. This latter committee had been established by the Council to assist in assessing the financial and other aspects of the acquisition of the computer system resulting from the Tender Evaluation Board's recommendations. (See also the section in this report on "The Council and its Committees".) This Committee invited the Director to negotiate with tenderers for revised proposals for the front-end system. The Council, after consideration of the recommendations, and comments made by the Tender Evaluation Board and the two Advisory Committees agreed

CRAY–1

in principle on the acquisition of a CRAY–1 as the main "number crunching" computer. Further, having reviewed proposals for the front-end system, the Council authorised the Director to enter into negotiations with Control Data Ltd. (UK) for the acquisition of a

CDC CYBER 175

CDC CYBER 175 as the front-end computer.

The contract with Cray Research Incorporated was signed on June

22, 1977 and the interim CRAY computer was installed at the Rutherford Laboratory in November 1977. It passed its acceptance test shortly thereafter and is now being used by the Centre for experimental forecasting and for the development of the operating system. (Further details regarding this contract will be found under "The Council and its Committees".)

The contract with Control Data Ltd. (UK) for the CYBER 175 computer was signed on November 28, 1977 after approval by the Finance Committee on behalf of the Council and the interim CDC CYBER 175 will be installed at the Rutherford Laboratory around New Year 1978. This means that the CDC 6600 computer installed at John Scott House will no longer be used by the Centre. The interim installations will give the Centre prior access to and time on the computers for the crucial development phases during the first half of 1978 at a financially attractive rate. Also, the development of the link between the CRAY and CYBER computers will be facilitated enabling acceptance of the complete linked system to be planned in Autumn 1978 shortly after permanent installation at the New Headquarters. The system will then be gradually built up, by adding further peripheral equipment, to its complete state in time for operational trials in 1979. The final planned configuration is shown in Fig. 1.

Final Configuration

Telecommunications

Although the Invitation to Tender for a Computer System for ECMWF called for the provision of telecommunications and graphics sub-systems in addition to main and front-end computers, it was finally decided that these systems should be dealt with separately, and would best be handled by special Invitations to Tender. Accordingly, following the decision to acquire a CYBER 175 as the front-end computer, the Invitation to Tender for a Telecommunications Sub-system for ECMWF was issued in July 1977, calling for proposals for a turnkey system (hardware and software), backed by direct access mass storage. A decision concerning the supply of the telecommunications system has now been reached and installation of the equipment and software is expected in late 1978. The system will interface to the standard hardware and software of the CYBER 175 and will control the communication lines to Member States, using internationally recommended and approved communications protocols. Facilities provided by the telecommunications sub-system are the transfer of files for acquisition of meteorological data and dissemination of forecast results via low and medium speed lines and the submission of computing tasks from remote stations via medium speed lines. The chosen contractor was Service in Informatics and Analysis Ltd. (UK) with A/S Regnecentralen (Denmark) as subcontractor.

Graphical Facilities

With regard to the graphical facilities, it was decided to build up to a full sub-system step by step. The first two steps were the acquisition of plotters and of terminals, and Invitations to Tender for these two items were issued in August. An on-line plotting system was selected comprising Versatec 8122 electrostatic plotters and the hardware and software for the on-line interface. Also, it was decided to acquire initially ten alphanumeric display terminals and one graphical display terminal. The graphics sub-system will be completed by the development of a device-independent graphical software package and the acquisition of facilities for computer output on microfilm.

Facilities Available to the Centre in 1977

The paragraphs above describe the facilities that will be available to the Centre in 1978 and after. However, the Centre needed computing

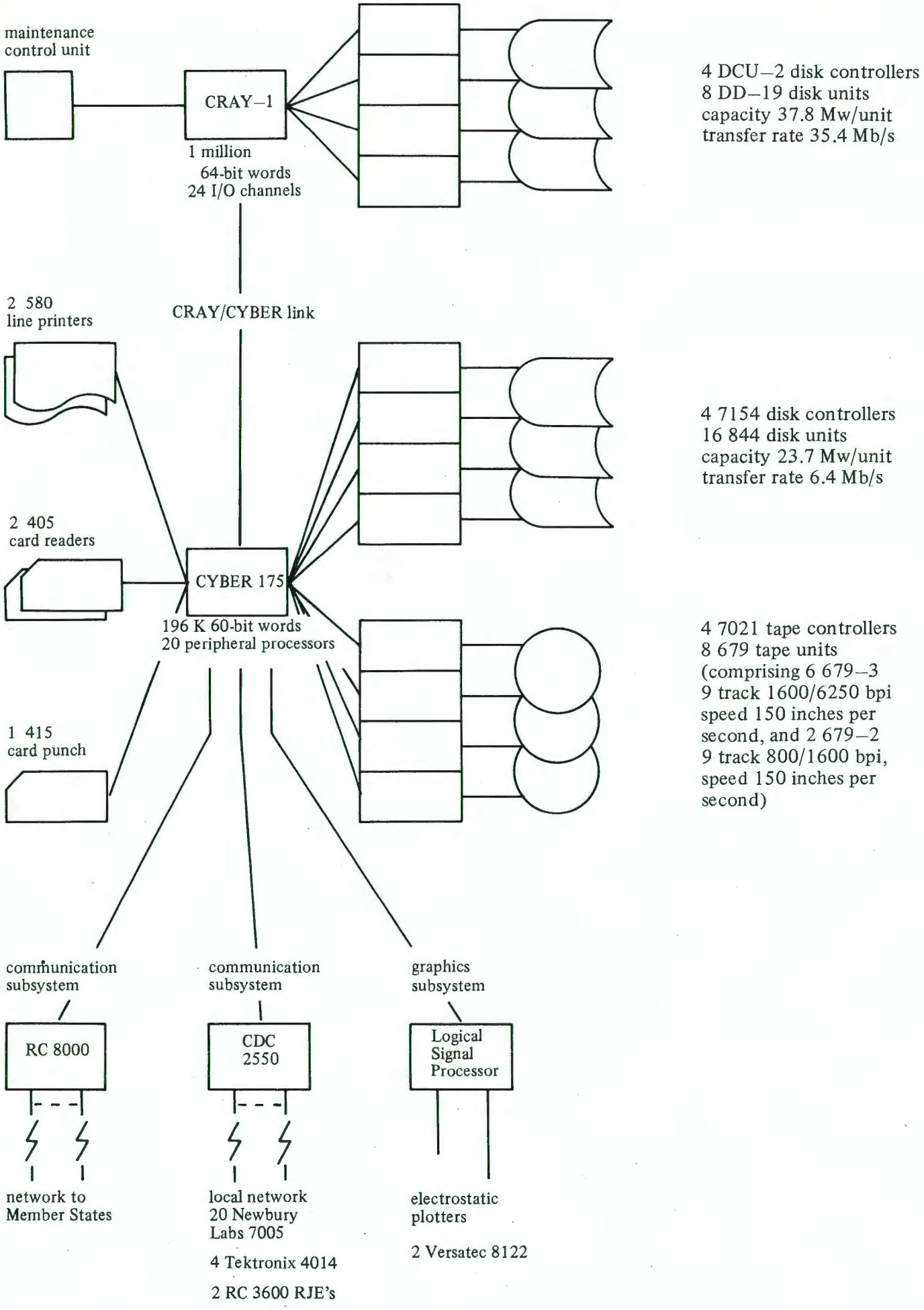


Fig. 1 Configuration diagram of ECMWF Computer System

and other technical facilities during 1977 to allow essential research and development work to proceed. This need has been met in a number of ways, most importantly on a day to day basis by the use of the CDC 6600 computer situated at John Scott House in Bracknell and dedicated entirely to the use of the Centre. Under the terms of a lease agreement with Control Data Ltd., this computer is available to the Centre 24 hours a day, 7 days a week. Up to August, a two-shift system of operator cover was provided, but a three-shift system was introduced at that time, giving 24 hour coverage on five days a week. However, following the installation and operation of the CRAY–1 computer at Rutherford also requiring manpower, it was necessary to revert to two-shift cover. At no stage of the year, however, was computer time wasted as it was possible to leave the large numerical forecasting models running unattended overnight and at weekends. Every month, on average, between 5000 and 6000 jobs were run on the CDC 6600; the CPU usage increased from about 200 hours per month at the beginning of the year to an average value of over 300 hours per month at the end. The monthly usage of the CDC 6600 is shown in detail in Fig. 2.

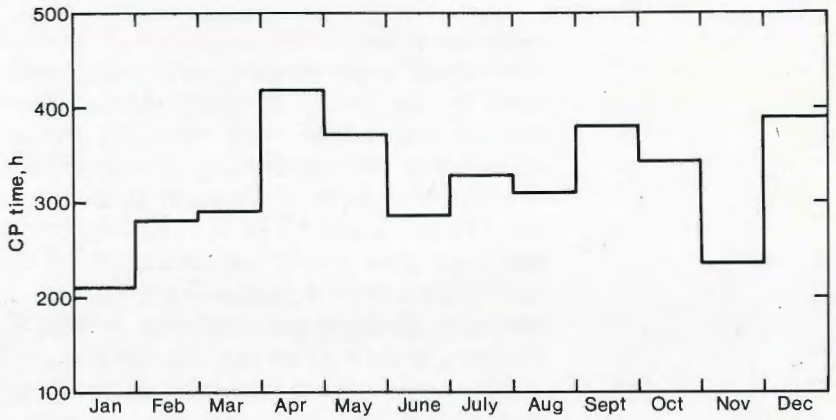


Fig. 2 CDC 6600 usage in 1977.

The Centre had access for a good part of 1977 to a CRAY–1 computer. Following the Council agreement on the acquisition of a CRAY–1 as the main computer, time was made available to the Centre from April on such a computer installed in the USA. To take full advantage of this, a member of the Operations Department staff spent six months in the USA becoming familiar with the CRAY operating system and Fortran compiler. In this way, useful assistance was provided to members of the Research Department during their visits to the USA to develop the forecasting and analysis schemes. Since November, the Centre has been making use of the CRAY–1 computer at Rutherford.

The third computer system which the Centre could have used to some extent in 1977 was the United Kingdom Meteorological Office IBM 360/195 - 370/158 complex (COSMOS). An agreement exists whereby the Centre can use limited quantities of time on this system. However, with the availability of the CDC 6600 at John Scott House, and computer time in the USA and at the Rutherford Laboratory, little use was made of the United Kingdom Meteorological Office system in 1977.

The Centre also has available in John Scott House an off-line plotting system, consisting of a Varian electrostatic plotter and tape drive. This has been of great value in enabling reading display of the results

from the numerical experiments. The average number of charts produced per week in 1977 was about 100.

Implementation of Operational Forecasting

A supply of synoptic meteorological data is the basis of operational forecasting, and it has been agreed that the United Kingdom Meteorological Office shall be the source of such data for ECMWF. Accordingly, there were discussions with the United Kingdom Meteorological Office as to how best and in which format the data should be supplied. It was finally decided that the data would best be obtained in the format in which it is transmitted on the Global Telecommunications System (i.e. in WMO bulletin format) via a link from the Bracknell Telecommunication Hub to the Centre. This means that, as part of the overall operational process, full checking, decoding and quality control programmes must be prepared but it is hoped to base these on a package available from the French National Meteorological Service. As an interim measure, decoding programmes were prepared to operate on observational data as held by the United Kingdom Meteorological Office in its data base; these programmes provided sets of data for testing the analysis system being developed in the Research Department.

More generally, work proceeded on planning all the various parts of the complete operational suite, with particular attention having been paid to the design of the Centre's observational data base. Other aspects which have been especially studied are those of scheduling, monitoring and controlling the operational suite and assessing the changes that have to be made in the standard operating systems of the CRAY–1 and CYBER 175 computers to support the operational suite. In this connection, members of the Operations Department staff visited the Deutscher Wetterdienst in Offenbach and the Direction de la Météorologie Nationale in Paris. Both these centres use CDC equipment to support operational forecasting and much useful information was gathered in relation to meteorological data processing and how it may be monitored and scheduled on CDC equipment.

The Advisory Committee on Communications between the Centre and Member States

The Operations Department provided extensive support to the Advisory Committee on Communications between the Centre and Member States in its work, both in the field of detailed technical telecommunications and meteorological aspects. In return, it received very valuable input and guidelines on the planning of the telecommunications facilities and operational forecasting at the Centre. The Advisory Committee recommended that communications between the Centre and Member States should be by use of a telecommunications network of medium speed lines (i.e. 2400 bps), although for technical reasons some low speed lines would have to be used initially. Further, the Advisory Committee agreed upon telecommunications protocols, based on those proposed by the Centre, to be used on the medium speed lines; these proposals would be the standard in the communications between the Centre and Member States. The Telecommunications section of the Operations Department was responsible for fully detailing these protocols, and incorporating them into the specifications in the Invitation to Tender for a Telecommunications Sub-system for ECMWF. Staff of the Operations Department also handled the issuing of a series of questions to Member States prepared by the Advisory Committee and the analysis of the replies. These questions requested detailed information on Member States' operational data requirements from the Centre and their technical facilities and plans for receiving and making use of the data. In the light of the answers and taking into account other relevant information, the Advisory Committee was

able to prepare detailed recommendations for the implementation of the telecommunications network linking ECMWF and Member States. These recommendations included a time-table for the connection of Member States to the Centre by medium speed lines, although low speed lines could be available to all Member States who so wished from the start of operational forecasting in 1979. The recommendations of the Advisory Committee were accepted by the Council at its sixth session in November.

Administration Department

Structure

In February 1977, the Administration Department moved into the third set of temporary accommodation, in Brandon House, Bracknell. The main tasks carried out in the course of the year by its four sections (Finance, Personnel, Supplies and General Services, Secretariat) were as follows :

Responsibilities

Finance Section — Implementation of Financial Regulations, preparation of updated ceiling of expenditure estimates and the budget 1978, preparation of a first draft of revised Financial Regulations, cash and accounts, periodic statements of accounts and accounting of assets etc.

Co-ordinated Organisations

The Head of the Administration Department continued to attend, as an observer, the meetings of the Co-ordinating Committee of Government Budget Experts and the Committee of Heads of Administration of the Co-ordinated Organisations. The Centre is not a full member of the Co-ordinated Organisations.

Ceiling of Expenditure

The ceiling of expenditure for implementing the programme of activities of the Centre over the five years following the entry into force of the Convention was unanimously approved by the Council at its first Session.

At its sixth Session held on 8-9 November 1977 the Council adopted the new ceiling of expenditure for the years 1978, 1979, 1980 and 1981 and determined that the amount of the Member States contributions to be paid during that period shall not exceed £22,779,880.

The increase of the estimated contributions due from the Member States for the years 1978/1980 over the ceiling of expenditure previously approved by the Council amounts to £83,000 i.e. 0.5%.

Scale of Financial Contributions

The estimated contributions due by the Member States towards the Budget 1977 amounted to £2,624,300. This figure also included the contribution payable by Italy who became a Member State, party to the Convention, effective from 1 September 1977. An additional contribution amounting to £131,970 is expected from Italy towards the expenditure incurred by the Centre during the first financial year and it will be returned to the Member States when credited to the Centre's account.

The scale of financial contributions of the 17 Member States party to the Convention is calculated on the basis of the Gross National Product (GNP) expressed in dollars of each of the Member States for the years 1971, 1972 and 1973.

The highest contributions towards the Budget 1977 were provided by Germany, France, Great Britain and Italy (69.69% of the total contributions) which are the four permanent Members of the Centre's Finance Committee. A scale of the financial contributions is shown in Annex 8.

Budget

The Budget 1977 of the Centre was adopted by the Council at its third Session held on 16-17 November 1976. The approved total

amount of the expenditure for the year 1977 was £2,970,000 with an increase of 47% over the estimated expenditure of the first Budget of the Centre. The expenditure was mainly covered by the Member States' contributions to which were added the proceeds of taxation, staff contributions to the pension fund and other minor revenue, e.g. refunds of taxes and bank interest.

During 1977 the financial needs of the Centre were mainly related to the operating expenditure of which the appropriation for the remuneration of the staff constituted the largest part of the Budget.

The important decision about the acquisition of the main computer system of the Centre had some financial impact on the implementation of the Budget 1977 owing to the payment of the rental and maintenance charges due to the manufacturer from 21 November onwards.

The investment expenditure in 1977 was mainly related to the acquisition of a Private Automatic Branch Exchange (PABX) for the permanent Headquarters of the Centre. Other investment expenditure was limited to the purchase of office furniture, office machinery and other minor items.

Commitment appropriations unused at the end of 1977 were carried forward into 1978 in order to provide the contract authority for payments due in 1979 and related to contracts to be signed during 1978.

Details of the estimated figures of the Budget 1977 which take into account transfers of funds authorised during the year, are tabulated below :

	Revenue	Expenditure	
		Commitment Appropr.	Payment Appropr.
Title I – Revenue	2,970,400		
Title II – Investment Expenditure		420,000	85,000
Title III– Operating		1,070,000	2,885,400
Total	2,970,400		2,970,400

The expected surplus to be returned to the Member States at the end of the financial year amounts to about £700,000.

Responsibilities

Supplies and General Services – Market surveys; tendering and contract procedures for the acquisition of equipment, furniture, supplies, and for contract maintenance of equipment and buildings; administration of transport, mail, switchboard, telex and courier services; management of document reproduction service, archives, library and inventory; organisation of the maintenance and security of the buildings and co-ordination of all action related to the new permanent Headquarters building at Shinfield Park.

Once the Centre moves into the new Headquarters building at Shinfield Park, this section will undertake additional services i.e. maintenance of the new buildings and grounds; restaurant supervision; simultaneous interpretation facilities; lecture theatre, classroom, accommodation facilities and so forth.

Purchases Contracts

Numerous purchase requests were raised during the year for items ranging from stationery to overhead projectors. Fourteen (14) Invitations to Tender were drafted, resulting in 103 responses, all of which were evaluated. Negotiations with thirteen potential contractors have commenced and will continue into the early part of 1978. Various maintenance and service agreements were entered into during the year and the Centre endeavoured to keep purchases for the 1977 requirements to a minimum.

Reproduction Service

A new service was established at the Centre in 1977, that of reproduction of the Centre's documents by the Centre's own offset printing equipment, resulting in a saving in costs and an improved and consistent quality of documents and reports.

Responsibilities

Secretariat — The Administration Department assisted the Director in organising and carrying out the secretarial tasks arising from the work of the Council, its Finance Committee, and other bodies. In 1977 there were three sessions of the Council and seven sessions of the Finance Committee. In this task, the Secretariat is assisted by **Linguists** whose responsibilities are: translation of documentation for Council and Finance Committee, scientific reports, and other texts, into the working languages of the Centre — i.e. English, French and German.

Responsibilities

Personnel Section — Staff legislation, assistance to Working Group on Staff Regulations in preparation of draft revised Staff Regulations, recruitment of staff, staff management including payment of salaries, allowances and expenses incurred while on duty.

Staffing

The Table of staff requirements for 1977, after some amendments made by the Council in the course of the year, contained 97 posts. For the major part of the year, 14 of these posts were blocked pending availability of funds from the contributions of Italy. However, at its November meeting, Italy having now become a Member State on 1st September 1977, the Council authorised the Director to employ staff in the posts previously blocked.

By 31 December 1977, there were 81 staff members and a few consultants and visiting scientists at the Centre. See Annex 1 for details of the staffing at 31 December 1977.

The Centre is still experiencing difficulties in recruiting new staff, in particular staff who are not UK nationals. All possible emphasis has been put upon trying to achieve a fair geographical distribution among the staff.

Staff Regulations

The Working Group on Staff Regulations continued its deliberations and presented its final report, together with a draft of the Staff Regulations, to the Finance Committee who subsequently presented it to the Council. At its 6th session in November 1977, the Council adopted the revised Staff Regulations of the Centre and agreed to consider proposed amendments submitted by the Member States, the Centre and the Staff Committee at a subsequent session. The Staff Committee contribution to this report will be found after the section on the Council and its Committees.

Social Security and Medical Health Insurance

With the adoption of the revised Staff Regulations by the Council, the Pension Scheme of the Centre became compulsory for all staff members. This means that resident staff have a double compulsory affiliation since they also have to contribute to the Social Security Scheme of the United Kingdom. This problem was discussed in meetings of the Co-ordinated Committee of Government Budget Experts of the Co-ordinated Organisations, but no solution has yet been found and negotiations are continuing between the Organisations concerned and the UK Government, in order to achieve an exemption from all compulsory contributions to the United Kingdom Social Security Scheme for all UK nationals. Such an agreement has already been concluded between the Centre and UK Government regarding non-resident staff.

The Centre has not yet been able to obtain medical insurance additional to the National Health Scheme of the host country under which all staff members are eligible for medical treatment. The staff, particularly the non-resident staff, still feel that the treatment provided by this Scheme is insufficient and below the standard to which they are accustomed. The problem is still under review by the Finance Committee.

Education

The Centre arranged a third seminar on the subject "Parameterization of physical processes in the free atmosphere" at the Meteorological Office College at Shinfield Park between 5-16 September 1977. The seminar was attended by about 50 participants in addition to the lecturers and Centre staff drawn from the Member States.

The main lectures were given by Prof. Arnt Eliassen, University of Oslo, Dr. Ray Bates, Irish Meteorological Office, Dublin, Dr. Clive Rodgers, University of Oxford and Dr. Hilding Sundqvist, University of Stockholm.

Prof. Eliassen dealt with problems connected with flow over mountains and in particular how steep mountains affect the atmosphere. Dr. Bates reviewed the work in the parameterization of convective processes and Dr. Sundqvist described the way in which precipitation processes in general could be parameterized in numerical weather prediction.

Finally, Dr. Rodgers gave a detailed exposé of the treatment of radiative processes in the atmosphere.

Contributions on individual topics were given by members of the Centre's staff who also presented the Centre's planned parameterization system.

Proceedings of the Seminar have now been published and distributed to delegates and the Member States.

Visiting Scientists

During 1977, the Research Department had six visiting scientists : Dr. W. Blumen from Colorado State University, Boulder, USA, Dr. D. Gauntlett from the Australian Numerical Meteorological Research Centre, Melbourne, Australia, Dr. I. Rutherford from the Atmospheric Environment Service, Montreal, Canada (Dr. Rutherford also served as Head of the Data Assimilation Section), Dr. B. Machenhauer, from the Institute for Theoretical Meteorology, University of Copenhagen, Denmark, Monsieur, J. Quiby from the Swiss National Meteorological Service and Dr. D. Williamson from the National Center for Atmospheric Research, Boulder, Colorado, USA.

Library

The Centre is building a scientific and technical meteorological library by the gradual acquisition of material. The main task of the library is to serve the needs of the Centre's staff. It may be also used by members of any Meteorological Department from member countries.

The contents of the library include: books and journals; technical publications; reprints; maps and atlases. The major part of the library consists of the books on meteorology and related subjects: oceanography, mathematics (computer science), and physics (fluid dynamics). The books are placed together in one section of the library and arranged in order of subject. The order of UDC is used.

The library is subscriber to over 70 periodical titles. Most of these titles are journals of meteorology. In addition to these there are journals of mathematics, oceanography, geophysics, physics and multidisciplinary journals. Efforts have been made to acquire all available back volumes of the leading journals in meteorological science.

Most of the technical publications are received under exchange agreements set up with the libraries in all member countries. A separate section is devoted to these publications and they are arranged geographically by countries.

Great care is devoted to the selection of books and journals. The books recommended for purchase by the staff members must be considered at a Library Group Meeting before they are placed on order. In doubtful cases when available information about the book is not sufficient guide to its value, a specimen copy is inspected before decision on purchase.

Items not held in the Library but required by staff members may be borrowed from other libraries. The main sources are British Lending Library and Meteorological Office Library which have an extensive library service.

A monthly accessions list is issued and widely distributed within the Centre.

The Council and its Committees

Council Sessions

In 1977 three sessions of the Council were held, on 30-31 March, 24 May, and 8-9 November. At the time of this last session, the number of Member States had risen to seventeen. Italy deposited its instrument of ratification of the Convention on 31 July 1977 and became a Member State on 1 September 1977.

Council Session, London – November 1977.

New Advisory Committee

The fourth Session of the Council was held in March in order to reach a decision on the acquisition of the computer system to be installed at Shinfield Park. It was necessary to hold an additional session in May to decide on the front-end computer to be acquired for this system. The Council was assisted in this task by its special Advisory Committee established to assist in assessing the various aspects of the acquisition of the computer system of the Centre, which met on 18-19 January and 8-9 March 1977 to consider the report of the Centre's Tender Evaluation Board and the implications of its recommendations.

Elections

At the 6th session of the Council, in November, the Council unanimously re-elected Professor L. Vuorela (Finland) and Mr. R. Mittner (France) as President and Vice-President for a second term of one year.

Finance Committee

The Finance Committee met for seven sessions in the course of 1977. Until 1 September 1977, the membership remained as in 1976 – the Federal Republic of Germany, France, Netherlands, United Kingdom, Belgium, Denmark and Spain. Upon Italy becoming a full member, the Netherlands delegation was replaced by the Italian delegation, representing one of the four Member States paying the highest contribution to the Centre's budget. At the November session of the Council, Ireland, the Netherlands and Yugoslavia were appointed to replace Belgium, Denmark and Spain, in representing the other Member States.

President, Director, Dr. von Noorden and Belgium delegation: Mr. Deloz, Dr. Struylaert.

Italian delegation: Prof. Cena, Mr. Mariani, Mr. Ghio.

French delegate: Mr. Mittner,
German delegate: Dr. Lingelbach.

Yugoslav delegation: Dr. Radinović, Dr. Lambasa with the Director.

President with the Danish delegation: Mr. Asmussen, Mr. Nielsen.

Mr. M. Deloz (Belgium), Chairman of the Committee since November 1975, came to the end of his term of office at the same time.

Council Session, London – November 1977. Mr. J.J.H. Jurgens and Dr. H.C. Bijvoet.

In the course of the year the Finance Committee was occupied not only with routine financial matters, such as consideration to the draft budget, the updated ceiling of expenditure estimates attached to the programme of activities, the Auditor's report on the previous financial year, etc., but also with detailed examination of the draft contracts for the Centre's computer system.

The draft contract between the Centre and Cray Research Incorporated, Minneapolis, USA, for the acquisition of the CRAY–1 computer, was approved by the Council at its May session. This contract is a rental agreement with the option to purchase at a later date. The Council, at the same session, delegated to the Finance Committee the power to approve the draft contract for the acquisition of the front-end computer. The Finance Committee subsequently approved this draft contract, between the Centre and Control Data Ltd., London, for the acquisition of a CDC CYBER 175 as the front-end computer for the Centre's computer system, at its 12th session on 7 November 1977. This contract also contains a rental agreement with purchase option. Maintenance agreements are contained in both contracts.

Scientific Advisory Committee

The Scientific Advisory Committee met twice in the course of the year, on 6-7 January and 7-8 September. Its Chairman, Mr. J. S. Sawyer, resigned for personal reasons in August 1977, and the resulting vacancy was filled when the Council, at its November session, appointed Mr. F. Bushby (UK) for a three-year term. At the same time, the Council re-appointed Dr. D. J. Bouman (Netherlands), Prof. E. Eliasen (Denmark) and Prof. K. Hasselmann (Fed. Rep. of Germany) for a second term of four years.

The Scientific Advisory Committee continued to review and advise on the work of the Centre, and at its fourth session recommended to the Council that further consideration should now be given to the determination of the Centre's long-term scientific activity.

Working Groups

Details of the Working Group on Staff Regulations of the Finance Committee, and the Advisory Committee on Communications will be found under the sections Administration Department and Operations Department respectively.

The Staff Committee

In its second year, the Staff Committee continued its tasks of representing the financial, social and professional interests of all staff members.

The Staff Committee is composed of two representatives from each department, elected every year. In 1977 regular monthly meetings were held between the Staff Committee, the Director, the Deputy Director of Administration, and the Head of Personnel to discuss problems involving the staff. (These discussions are held in a spirit of co-operation since the Staff Committee does not consider itself as representing the staff against the administration but rather as an intermediary between the Directorate and the Staff.)

An important event of 1977, as far as the staff was concerned, was the adoption by the Council of the Staff Regulations of the Centre. The Staff Committee followed closely the elaboration of these regulations and had been able to advise the Working Group and to propose several amendments to the draft, many of which were adopted by the Working Group.

Another aspect of the role of the Staff Committee is to establish relationships with the staff of other Co-ordinated Organisations. To this effect, a member of the Staff Committee was sent to the meetings of the Standing Committee of Staff Associations of the Co-ordinated Organisations. Despite its role of observer, the representative of the Centre was allowed to participate in the discussions and to stress the specific problems of European staff working in the United Kingdom. This representation, however, was suspended at the end of 1977 when the Council blocked the funds allocated to the Staff Committee in the Centre's Budget.

Finally, after the election of a new Committee in October, a general meeting of staff was called at which the Head of Personnel introduced the newly adopted Pension Scheme of the Centre.

Annex 1

Staff at 31 December 1977

Director	A.C. Wiin-Nielsen	Denmark
Deputy Director (Head of Research Department)	L.O. Bengtsson	Sweden
Deputy Director (Head of Operations Department)	J. Labrousse	France
Deputy Director (Head of Administration Department)	W.D. von Noorden	F.R.G.

Distribution of staff by grade and nation

	Grade					
	h.g.*	A	B	C	L	Total
Belgium		2				2
Denmark	1	2				3
F.R.G.		6	3		1	10
France		4	3		1	8
Ireland		2				2
Italy		4	1			5
Yugoslavia			3			3
Netherlands		3	1			4
Austria		1				1
Finland		1				1
Sweden		4				4
United Kingdom		20	16	2		38
Totals	1	49	27	2	2	81

* Hors grade

3 consultants and 1 visiting scientist were also employed by ECMWF at 31 December 1977.

Annex 2

Members of the Council

President	L.A. Vuorela	Finland
Vice-President	R. Mittner	France
	A. Vandenplas	Belgium
	M. Deloz	Belgium
	K. Andersen	Denmark
	L.B. Asmussen	Denmark
	E. Lingelbach	F.R.G.
	H.G. Schulze	F.R.G.
	I. Font Tullot	Spain
	R. du Chaxel	France
	A. Bassiakos	Greece
	P.M. Austin-Bourke	Ireland
	G. Cena	Italy
	M. Mariani	Italy
	D. Radinović	Yugoslavia
	A. Lambasa	Yugoslavia
	H.C. Bijvoet	Netherlands
	J. Jurgens	Netherlands
	K. Cehak	Austria
	F. Cabrita	Portugal
	G. Simmen	Switzerland
	E. Marthaler	Switzerland
	D. Söderman	Finland
	O. Lönnqvist	Sweden
	B. Gellstedt	Sweden
	A. Rumeli	Turkey
	Y. Erbatz	Turkey
	B.J. Mason	U.K.
	C.P. Lynam	U.K.
	R. Schneider	WMO Observer

Annex 3

Finance Committee

Chairman : M. Deloz (Belgium)

The Finance Committee is composed of representatives of those four Member States paying the largest contributions to the Centre, and representatives of three other Member States designated by the remaining Member States. In 1977 the Committee was composed as follows :

i) *Those paying the largest contributions :*

Federal Republic of Germany
France
Netherlands
United Kingdom

ii) *Those designated by the remaining Member States :*

Belgium
Denmark
Spain

Since Italy became a Member State on 1st September 1977, and on the expiry of the terms of office of those States representing the three groups of Member States other than those four paying the highest contribution to the budget, at its 6th Session in November 1977, the Council took note that the delegates to the Finance Committee would now be :

i) Federal Republic of Germany, France, United Kingdom, Italy

ii) Ireland (representing also Denmark, Finland, Sweden)
Yugoslavia (representing also Spain, Greece, Portugal, Turkey)
Netherlands (representing also Belgium, Austria, Switzerland)

Annex 4

Members of the Scientific Advisory Committee

The Scientific Advisory Committee is composed of the following members selected by the Council in their personal capacity :

Chairman :	J.S. Sawyer*	U.K.
Vice-Chairman :	F. Mesinger	Yugoslavia
	J.R. Bates	Ireland
	D.J. Bouman**	Netherlands
	P. Morel	France
	K. Hasselmann	F.R.G.
	E. Eliasen	Denmark
	E. Holopainen	Finland
	S. Palmieri	Italy
	J. van Isacker	Belgium
	F. Wippermann	F.R.G.
	B. Döös	Sweden (WMO Representative)

*J.S. Sawyer has now resigned from the SAC upon his retirement and the new Chairman of the SAC is J.R. Bates (Ireland).

Accordingly, at its November Session the Council appointed Mr. F. H. Bushby (UK) to fill the vacant place.

**Dr. C. Schuurmans (Netherlands) was appointed to the SAC in place of Dr. D.J. Bouman who died in December 1977.

Annex 5

International Meetings attended by Members of Staff

1977

10-12 January	Meeting of FGGE Board of the JOC, Geneva	Director (as JOC Representative)
14-18 February	Executive Committee Meeting for Inter-governmental Panel on FGGE, Geneva	Director (as JOC Representative)
25-27 February	EEC Steering Committee on European Climate, Brussels	Director (as Chairman)
18 March	ESA Space Meteorology Working Group, Paris	L. Bengtsson
28 March - 1 April	Conception des Réseaux Informatiques, IRIA, Paris	P. Quoilin
21-23 April	FGGE Study Conference, Stockholm	Director L. Bengtsson
23-24 April	Level III-b Board of Review, Stockholm	Director
25-26 April	JOC Working Group on Numerical Experimentation, Stockholm	Director L. Bengtsson
28 April	Presentation of X25 Interface, London	J. Hennessy K. Wilke
16-17 May	FGGE Level II and III-b Data Planning Meeting, Norrköping, Sweden	G. Larsen
25-27 May	Second Session of Advisory Committee on Communications between ECMWF and Member States, Reading	J. Labrousse F. Königshofer R. Newson
8-10 June	Experts Meeting on Graphical Applications in Meteorology, Helsinki	K. Petersen
9-10 June	Meeting of Scientific Advisory Committee, Max-Planck Institute, Hamburg	Director
25-26 July	Communications Committee of ECODU (European Control Data Users' Group), Paris	F. Königshofer
8-12 August	Tri-annual Conference of the International Federation for Information Processing (IFIP), Toronto	R. Brinkhuysen K. Wilke
22-25 August	Visit to United States National Weather Service, Silver Springs, Maryland, USA	R. Newson
22 August - 2 September	IAGA/IAMAP Joint Assembly, Seattle, USA	Director L. Bengtsson R. Newson

5-8 September	Visit to Deutscher Wetterdienst, Offenbach	J. Martellet B. Norris
13-16 September	Third Session of Advisory Committee on Communications between ECMWF and Member States, Madrid	J. Labrousse R. Newson
21-23 September	Fourth European Network User Workshop, Berlin	K.Wilke
26-29 September	Joint Conference of Control Data Users Group, VIM/ECODU, Montreux	R. Friedman M. Lewis N. Storer
2-6 October	FGGE Planning Meeting, USSR	G. Larsen
3-4 October	Visit to Météorologie Nationale, Paris	J. Martellet
3-7 October	International Symposium on Teleprocessing Computer Networks (organised by IFIP), Budapest	F. Königshofer
10-11 October	Level III-b Data Meeting, ECMWF, Bracknell	Director G. Larsen
24-28 October	Planning Meeting on the GARP Mountain Sub-Programme, Venice, Italy	Director (Chairman) S. Tibaldi
29 October	Meeting of the JOC Board on the Mountain Sub-Programme, Venice, Italy	Director (as JOC representative)
14-15 November	Software Management Conference on Government Programmes, Munich	R. Brinkhuysen
21 November - 2 December	Working Group on the Global Telecommunications System, (Eighth Session), Geneva	J. Hennessy
24-25 November	Seminar at Exeter University	Director

Annex 6

Publications by Members of Staff

Bengtsson, L.	Growth rate and vertical propagation of the initial error in baroclinic models. (Accepted for publication in Tellus)
Bengtsson, L.	Initial data and some practical aspects of weather forecasting, NCAR Summer Colloquium 1976, Weather Forecasting and Weather forecasts. Model, Systems and Users. pp. 254-419, pp. 663-671, pp. 721-733.
Burridge, D.M.	The stability of the semi-implicit method of time integration, by Simmons, A.J., Hoskins, B.J. and Burridge, D.M. (Accepted for publication in Monthly Weather Review)
Louis, J-F.	Transport by mean and turbulent motions in the stratosphere, in The Upper Atmosphere. Chapter 6, (Danielsen, E.F., and Louis, J-F.), Geophysics Research Board Monograph, National Academy of Sciences, Washington, DC., 1977.
Machenhauer, B.	On the dynamics of gravity oscillations in a shallow water model, with applications to normal mode initialisation, Beiträge zur Physik der Atmosphäre, 50 Band, pp. 253-271, 1977.
Newson, R. (with A. O'Neill of United Kingdom Meteorological Office)	Studies of Stratospheric Sudden Warmings simulated by a General Circulation Model of the Atmosphere, Contributions at CMUA Sessions, IAGA/IAMAP Joint Assembly 22 Aug. - 3 Sept. 1977.
Wiin-Nielsen, A.C.	Report by the Steering Committee for European Climate Research to the Commission of the European Communities.
Wiin-Nielsen, A.C.	On Geostrophic Adjustments in Numerical Procedures in a Rotating Fluid – Janjic, J. and Wiin-Nielsen, A.C., Journal of Atmospheric Science, February 1977.

Annex 7

ECMWF Publications

Internal Reports (Research Department)

No. 1 User's Guide for the GFDL Model (November 1976)

No. 2 The effect of Replacing Southern Hemispheric Analyses by Climatology on Medium Range Weather Forecasts

No. 3 Test of a Lateral Boundary Relaxation Scheme in a Barotropic Model

No. 4 Parameterization of the Surface Fluxes

No. 5 An Improved Algorithm for the Direct Solution of Poisson's Equation over Irregular Regions

No. 6 Comparative Extended Range Numerical Integrations with the ECMWF Global Forecasting Model 1: The N24, Non-Adiabatic Experiment

No. 7 The ECMWF Limited Area Model

No. 8 A Comprehensive Radiation Scheme designed for Fast Computation

No. 9 Documentation for the ECMWF Grid-Point Model

No. 10 Numerical Tests of Parameterization Schemes at an Actual Case of Transformation of Arctic Air

No. 11 Analysis Error Calculations for the FGGE

No. 12 Normal Modes of a Barotropic Version of the ECMWF Grid-Point Model

No. 13 Direct Methods for the Solution of the Discrete Poisson Equation: Some Comparisons

No. 14 On the FACR (ℓ) Algorithm for the Discrete Poisson Equation

No. 15 A Routine for Normal Mode Initialisation with Non-Linear Correction for a Multi-Level Spectral Model with Triangular Truncation

No. 16 A Channel Version of the ECMWF Grid-Point Model

Technical Reports (Research Department and Directorate)

No. 1 A Case Study of a Ten Day Prediction (November 1976)

No. 2 The Effect of Arithmetic Precision on some Meteorological Integrations

No. 3 Mixed-Radix Fast Fourier Transforms without Reordering

No. 4 A Model for Medium-Range Weather Forecasting – Adiabatic Formulation

No. 5 A Study of some Parameterizations of Sub-Grid Processes in a Baroclinic Wave in a Two-Dimensional Model

No. 6 The ECMWF Analysis and Data Assimilation Scheme – Analysis of Mass and Wind Fields

No. 7 A Ten Day High Resolution Non-Adiabatic Spectral Integration: A Comparative Study

No. 8 On the Asymptotic Behaviour of simple Stochastic-Dynamic Systems

Others **Operations Department** (K. Petersen)

User's Guide for ECMWF Contour Packaging, ECMWF 1977.

Research Department

The Parameterization of the Physical Processes in the Free Atmosphere, ECMWF Seminars September 1977.

Annex 8

Scale of Contributions by Member States

Belgium	3.43%
Denmark	2.02
Federal Republic of Germany	25.56
Spain	4.40
France	18.48
Greece	1.23
Ireland	.52
Italy	11.11
Yugoslavia	1.72
Netherlands	4.41
Austria	1.97
Portugal	.82
Switzerland	2.97
Finland	1.29
Sweden	3.93
Turkey	1.60
United Kingdom	14.54
Total :	100.00%