Annual Report 1979

European Centre for Medium Range

Weather Forecasts

Contents

Prof. Lauri A. Vuorela, President of the Council

Foreword

As my foreword to the Annual Report for 1979, I think it is appropriate to repeat some of the remarks I made on the occasion of the official opening of the Centre's permanent headquarters in June 1979.

> 'It is extremely gratifying to realise, now, how promising the situation looks at the Centre. The number of staff has now reached 130 – very near the eventual full complement of 140. Quality counts as much as (or even more than) quantity, of course, and there again I am happy to say that in the members of staff of the Centre we have some of the most highly educated and best scientific brains to be found in Europe.
>
> Much care and attention has been given in the selection of the Centre's computers, and we now have a formidable system combining a CRAY-I with a CDC CYBER 175. These computers have been available for use by the Centre since mid-1978, and the results of experiments carried out since then give high hopes for the success of the medium-range forecasts to be produced in the future. In fact it will not be long before these forecasts are produced regularly and sent out to the Member States via the telecommunications system being set up at the moment.
>
> Most of us here will have noticed how interest in meteorology and its implications has increased over the past ten years or so. It is not only in Meteorological Services that the potential benefits are recognised, but also in the European Economic Community, the Organisation for Economic Co-operation and Development, the European Space Agency and many other organisations and institutions. It must be the hope and expectation of all of us who are involved in any way with the Centre that its output will, to a very great extent, enable these benefits to be felt.''

In conclusion, as this has been the last year of my service as President of the Council, I would like to express my thanks to all my colleagues who have so ably assisted me in my task over the last three years, as well as the Director and his staff for their impressive contribution to the development of the Centre. The achievements of the Centre are in a large part due to the efforts of its staff and I have full confidence in its future.

I also wish to thank the United Kingdom Government for its perfect role as host country for the Centre. My own involvement with the Centre has been a pleasure thanks to the colleague to colleague relationship with the Council and the directorate of the Centre. I wish you all a prosperous future.

Lauri A. Vuorela

Introduction

Shinfield Park

The first months of 1979 were dominated by the continuing construction of the conference building and the incomplete status of the grounds and roads. Following some very hectic last week preparations it became possible to host the spring session of the Council in the new conference building on June 13–14, 1979 followed by the official opening on June 15.

Official Opening

The new headquarters for the Centre were opened by H.R.H. Prince Charles, K.G., K.T., P.C., G.C.B. who was accompanied by the Lord Lieutenant of the County of Berkshire, Colonel the Honourable Gordon Palmer. The royal party was received by the President of the Council, Professor L.A. Vuorela, the Vice-President, Mr. R. Mittner and the Director. The Prince unveiled a commemorative plaque in the presence of invited guests, members of the Council and its committees and the staff of the Centre. The plaque is located in the reception area of the Centre.

Unveiling of the commemorative plaque by H.R.H. Prince Charles, K.G., K.T., P.C., G.C.B.

The Prince, accompanied by the President, the Vice-President and the Director inspected the computer suite and meteorological operations room. Following the tour, the opening ceremony took place in a marquee erected adjacent to the Centre in the grounds of the Meteorological College operated by the British Meteorological Office. The Director welcomed His Royal Highness and the 300 invited guests and expressed, on behalf of the Centre, his appreciation to the United Kingdom Government for the excellent building complex provided for the future activities of the Centre. He mentioned, in particular, the excellent cooperation which had existed during the building phase between the Centre and various government departments such as the Meteorological Office, the Ministry of Defence, the Foreign and Commonwealth Office, the Department of the Environment, and, above all the Property Services Agency which had been in charge of the construction project carried out by the John Laing Construction Limited.

H.R.H. Prince Charles, K.G., K.T., P.C., G.C.B. discussing with the Director, Dr. A.C. Wiin-Nielsen, Professor L. Vuorela, the President of the Council and Mr. R. Mittner, the Vice-President of the Council.

H.R.H. Prince Charles, K.G., K.T., P.C., G.C.B. on his way to the Marquee for his inaugural speech, accompanied by the Director, Dr. A.C. Wiin-Nielsen, and the Lord Lieutenant of the County of Berkshire, Colonel the Honourable Gordon Palmer.

In reply, the Prince made a speech in which he mentioned the benefits of accurate weather forecasts to agriculture and other sectors of society. He also said that the Centre is obviously a great step forward and a most useful exercise in European cooperation.

H.R.H. Prince Charles, K.G., K.T., P.C., G.C.B. during his inaugural speech with the Director, Dr. A.C. Wiin-Nielsen and the Lord Lieutenant of the County of Berkshire, Colonel the Honourable Gordon Palmer.

Professor L.A. Vuorela accepted the building on behalf of the Council. In his speech the President gave a brief historic account of the creation of the Centre leading to the ratification of the Convention, the building project, the computer acquisitions and the operational forecasts to appear in the near future. The President concluded by presenting a cut-glass decanter to His Royal Highness. A substantial cheque was also sent to the Prince's Trust.

Among the special guests invited to the opening ceremony were:

Dr. E. Süssenberger, former President of the Council; Dr. M. Schregardus, former Vice-President of the Council; Dr. A. Bourke, former Council member; Mr. I. Font Tullot, former Council member; Dr. A. Nyberg, former Council member; Mr. G. Cena, former Council member; Mr. R. du Chaxel, former Finance Committee member; Mr. O. Morgan, former Finance Committee member.

The Centre expresses its appreciation to the British Meteorological Office, the Meteorological College and the Property Services Agency for their excellent assistance in arranging the opening ceremony.

Computers & Telecommunications

The CRAY-1, Serial No. 9 and the CDC CYBER 175 passed the final acceptance tests during 1979. Since then they have functioned well, achieving a performance rate over the minimum stipulated in the contracts. The telecommunications computer, RC 8000, was delivered by A/S Regnecentralen (Denmark), a subcontractor to Service in Informatics and Analysis (UK). The RC 8000 has also passed the acceptance tests

during 1979 and is presently employed in issuing forecasts to those Member States with which telecommunication lines have been established (see p. 20).

The Council decided during the year to purchase the CRAY-1 and the CDC CYBER 175. The original rental contracts have been discontinued. The purchases were financed over five years by an agreement with Lombard North Central Limited.

Use of Computer System by Member States

The Member States have increased their use of the Centre's computer system during the year. The full implementation of the scheme adopted by the Council and an efficient remote entry system must await the completion of the establishment of the telecommunications network. Nevertheless, many Member States have started to make use of the system in connection with national research projects related to numerical weather prediction. Special projects requiring time beyond the national allocation have been approved.

Operational Forecasts

The Centre commenced operational forecasting on an experimental basis on August 1, 1979. This event marked the completion of several years of work by the Research and Operations Departments. The first operational model of the Centre is a global grid-point model with a horizontal grid size of 1.875° longitude/latitude and 15 levels in the vertical direction. The model employs a staggered finite difference scheme on the so-called Arakawa C-grid. It contains parameterization schemes for air-sea interaction processes such as the turbulent fluxes of heat, moisture and momentum, for dry and wet convection, for radiation and clouds, for the heat balance over land, snow and ice, and for the influence of mountains on the atmospheric flow. The model is an atmospheric model. The oceans are represented by a sea surface temperature which is kept constant at each grid-point during the forecast.

Quality of Forecasts

The quality of the forecasts varies with season and with the meteorological situation. On some occasions it turns out that the forecasts are remarkably good up to 10 days, while in other situations the practical limit of predictability is less than a week. Experiments seem to show that a good forecast obtained from the operational model can also be obtained from other models available at the Centre such as a spectral model with corresponding resolution or a grid point model with a somewhat modified parameterization package. This statement does not mean that the various forecasts are identical, but that they behave in similar fashions. One possible explanation of this experience is that the accuracy of a forecast for 4–10 days depends strongly on the accuracy of the initial state. If so, it becomes extremely important to maintain in the future a set of observing systems which will permit a specification of the initial state at least as accurately as today. The Centre may indeed have been fortunate that operational forecasts have started during the year of the Global Weather Experiment during which a greatly enhanced set of observations exists, in particular in the low latitudes. In spite of the indication of a strong dependence on the accuracy of the initial state, the Centre has much work to do in trying to improve the numerical procedures and the parameterization of the physical processes.

GARP Activities

The data gathering phase of the First Garp Global Experiment (FGGE) finished on December 1, 1979. The experiment, including two special observing periods, lasted for one year. After much preparatory work the Centre has now commenced the production of global analyses for each day of the FGGE year. Because of a complicated data management system containing many parts there has been some delay in obtaining all data at the data collection centres (II-b data) in the USSR and Sweden but the initial difficulties appear to have been overcome. The Centre is very

grateful to the Norwegian Meteorological Institute, the Japan Meteorological Agency, the Australian Weather Bureau, and the National Meteorological Centre, USA, for seconding meteorologists to participate in the production of the III-b data set at the Centre.

Seminar & Training

The first training course at the Centre for meteorologists from the Member States took place during the period May–July, 1979. It was attended by eight meteorologists. Formal lectures were given on topics closely related to the Centre's research and operational activities including data processing, analysis initialization, numerical procedures, physical parameterization, and a study of the various models available at the Centre. In addition to attending the lectures each participant worked closely with a staff member to obtain some research experience.

Although the format of the training courses will be changed in the future to consist of several shorter courses arranged in a modular fashion it appears that the need for the training activities will continue to exist for some time.

The annual seminar in 1979 was devoted to the topic: "Dynamic Meteorology and Numerical Weather Prediction". The Proceedings from the seminar will be published shortly.

International Activities

The Director has continued his work as an officer and member of the Joint Organising Committee during the year. He has also served as the Chairman of the FGGE Board under the Joint Organising Committee. The Head of the Research Department has served as Chairman of the Working Group on Numerical Experimentation under the Joint Organising Committee and as Chairman of the Working Group on Numerical Weather Prediction under the Commission on Atmospheric Science, World Meteorological Organisation.

The Director retired at the end of 1979 as President of the International Commission on Dynamic Meteorology under the International Association for Meteorology and Atmospheric Physics (IAMAP). He has also retired as a member of the Scientific Advisory Committee to the Director-General of the European Space Agency and as Chairman of the Working Group on Earth-oriented Research within the European Space Agency.

During September, 1979 the Director accompanied the President of the Council on a visit to the National Weather Service of the People's Republic of China.

Concluding Remarks

In presenting the Annual Report for 1979 to the Council I should like to express my deep appreciation to the Members of the Council and its Committees for the cooperation and understanding which you have shown towards the Centre, its Director and Staff during the first six years of the Centre's planning and existence. I sincerely hope and trust that the confidence which you have shown in me will be transferred to my successor.

Research Department

Structure and Responsibilities

The Research Department is divided into two parts, a Data Division and a Model Division. The Data Division is mainly concerned with the collection and analysis of meteorological data and forecast verification, whereas the Model Division has the responsibility for the development of the Centre's forecast models.

The Data Division consists of three sections, namely Diagnostics, Data Assimilation and FGGE, with the following responsibilities:

Diagnostics	– Development of diagnostic and verification systems for numerical models; construction and maintenance of the research data bases.
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 systems to assess the meteorological observing network requirements.
FGGE	– Planning, development and production of the FGGE level III-b data set.

The Model Division consists of two interrelated sections, Numerical and Dynamical Aspects and Physical Aspects. These sections have the following responsibilities:

Numerical and Dynamical Aspects	– Development of the basic dynamical and numerical formulation of the Centre's forecasting models.
Physical Aspects	– Development of parameterization schemes to account for the sub-grid scale processes in numerical models.

Highlights

The major events of the year were the beginning of operational forecasting in the summer and the beginning of the production of final FGGE analyses towards the end of 1979.

The achievement of the operational target on schedule has required intense effort from the Research Department in the development of the data assimilation system and the forecasting model. The extensive testing of the data assimilation scheme by the FGGE group in the course of their preparation for FGGE production has led to many improvements in the system.

In addition to the main operational forecasts produced by the global grid point model, the global spectral model is being run routinely once a week on an experimental basis.

Analysis System

A great deal of development work has been done on the analysis system. It has been extended to perform the analysis with the same horizontal resolution as the forecast model and at 15 levels up to 10 mb. The upper level height analyses agree well with those produced by other Centres, while the vorticity fields seem to show more organised and intense struc-

tures than we had anticipated. It is not clear to what extent these features contribute to the vigorous behaviour of the forecast model which is discussed below. On the other hand the surface analyses tend to be smooth.

A great deal of work remains to be done on refining the analysis scheme. It is gratifying, nevertheless, that the scheme has worked so well and has proved very robust in operational use.

Development of the non-linear normal mode initialization scheme has continued. Large gains have been made in efficiency. The major changes made by the initialization are in the surface pressure field which is perhaps the best observed meteorological quantity. Current investigations are directed towards eliminating the larger scale changes in this field. Comparisons of the vertical velocity fields of the initialized analyses with vertical velocities calculated from the mass field using the omega equation show very good agreement in the positions and intensity of the dominant mid-latitude features. There are differences in areas where the vertical velocity fields are weak. Investigation of the effect of the initialization on the Hadley circulation is continuing.

Diagnostics

The work of the Diagnostic Section has continued to meet the growing demands put upon it. An extensive range of diagnostics is produced automatically after each forecast run for the Research Department.

As a result of a variety of special investigations a great many new diagnostic quantities have been available as options.

Two comprehensive diagnostic packages were developed for running as part of the operational suite and were introduced towards the end of the year. These are mainly concerned with studies of the energetics of the models. In addition development of a new set of routines to study the model's behaviour in frequency wavenumber space was begun.

Models

The Model Division has now developed three large scale numerical models for either operational weather forecasting or experimentation.

These are global/hemispheric grid point and spectral models and a limited area fine mesh model. Semi-implicit and explicit time-stepping schemes are available for each model as is a large variety of horizontal smoothing schemes. All these models can be used with the physical parameterization schemes developed at ECMWF (Tiedtke *et al.* 1979) and the 1965 version of the GFDL parameterization package. Although the models have been programmed to run at any resolution, most production integrations are carried out with the following 15 level "standard" versions:

Grid point model – 1.875° grid (N48); 3.75° grid (N24).

Spectral model – T63 (triangular truncation at total wavenumber 63);
T40 (triangular truncation at total wavenumber 40).

In addition a comprehensive diagnostics package is available to monitor each individual component of the models.

Work has started on the documentation of both the theoretical basis and the computer programs for the models. It is hoped that this project will be completed by mid 1980.

During 1979 two new projects were initiated:
(i) the development of a hybrid pressure/sigma – coordinate scheme and

(ii) a project to assess the impact on the 10-day forecasts, of using different and less smooth orography fields.

It is expected that a hybrid vertical co-ordinate model will be particularly useful for data assimilation and analyses in the stratosphere.

Model Performance

The first series of forecast experiments with the 15 level N48 global grid point model, the results of which were summarized in the 1978 Annual Report, revealed the following deficiencies:

a) acceleration of the zonal flow in middle latitudes of the northern hemisphere, and deceleration in the tropics, which results in a significant northward shift of the sub-tropical jet;

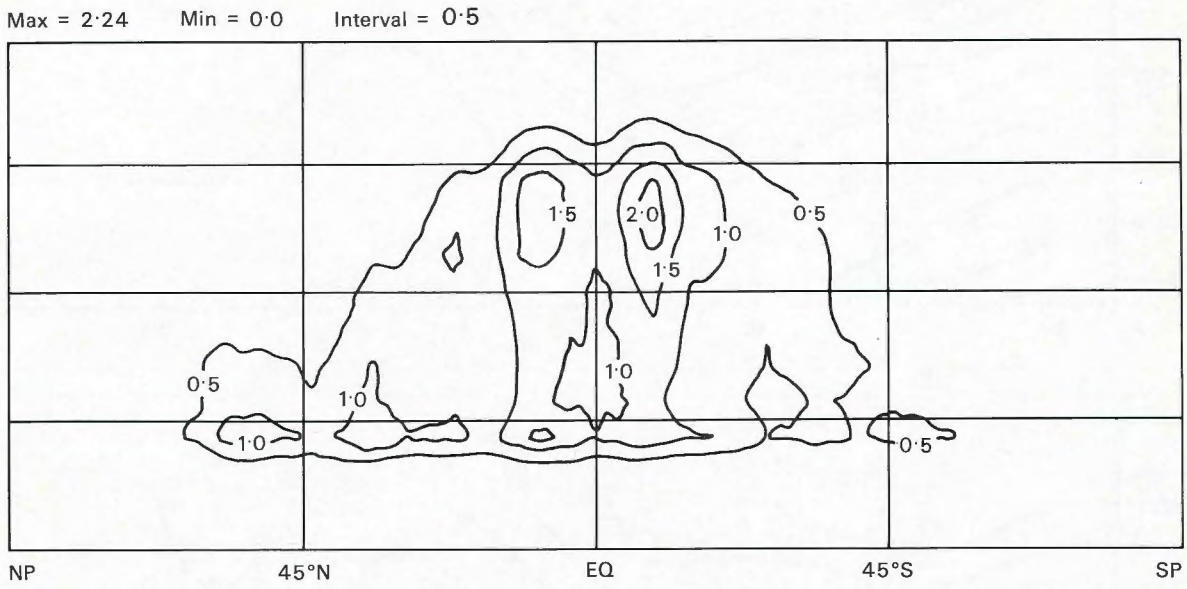
b) over-development of surface features in the model, and in the middle latitudes excessive latent heat release in the lowest model layers;

c) decline in the kinetic energy of the long waves, zonal wavenumbers 1 and 2.

One contributing effect to the spurious northward drift of the sub-tropical jet has now been identified. This is the development of an unreasonable vertical profile of convective heating with very large values in the tropical upper troposphere. By redefining the cloud base parameters for the Kuo convection scheme, which effectively reduced the energy available for convection, a much more realistic vertical distribution of convective heating was obtained and, as a consequence, the northward drift was almost completely removed from the ten-day forecasts. Figure 1 illustrates the performance of the two convection schemes. The original scheme produced more heating at higher levels, which was not balanced by radiative cooling. The improvement in the structure and position of the sub-tropical jet is illustrated in Figure 2. In longer integrations to 50 days the model still has a tendency to move the jet northwards, and in most of these long integrations a 5° latitude shift is observed.

In the last two months of 1979 it has been discovered that the model is remarkably sensitive to the various parameters that prescribe the surface fluxes of heat, moisture and momentum. The present formulation gives, under all conditions, a larger exchange coefficient for heat and moisture than for momentum. A revised formulation in which the exchange coefficient for heat and moisture is larger than the coefficient for momentum in unstable situations and smaller in stable situations has been evaluated in extended integrations, to 50 days, with the 15 level – T40 spectral model. The performance of the two formulations is illustrated in Figure 3 by 25 day means of 1000 mb heights taken from the last 25 days of these 50 day integrations. Compared to the original scheme this revised formulation gives a better climatology, fewer intense surface lows and has less of a tendency to produce very large scale features. It remains to be seen if this formulation will result in less intense surface developments in the operational ten-day forecasts.

The reasons for the decline of the longest waves during the forecasts are not yet understood. The experiments with different and less smooth orography fields may provide some understanding of this aspect of our models.



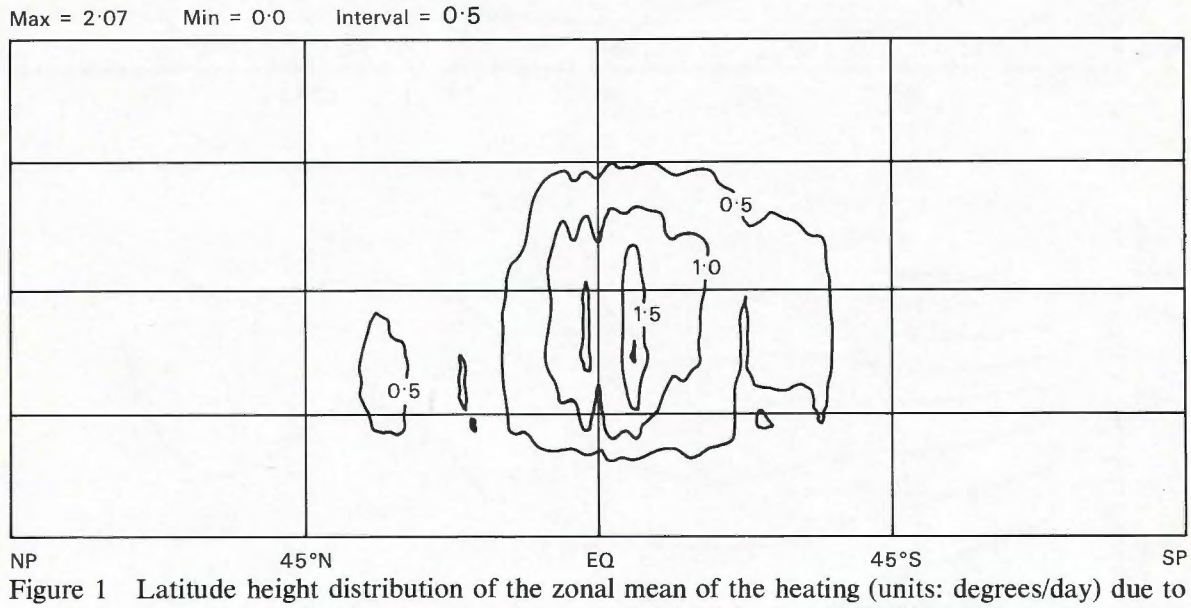


Figure 1 Latitude height distribution of the zonal mean of the heating (units: degrees/day) due to moist convection for a ten-day forecast. (Initial data time 00GMT 22/2/76). Original convection scheme (upper frame); revised convection scheme lower frame.

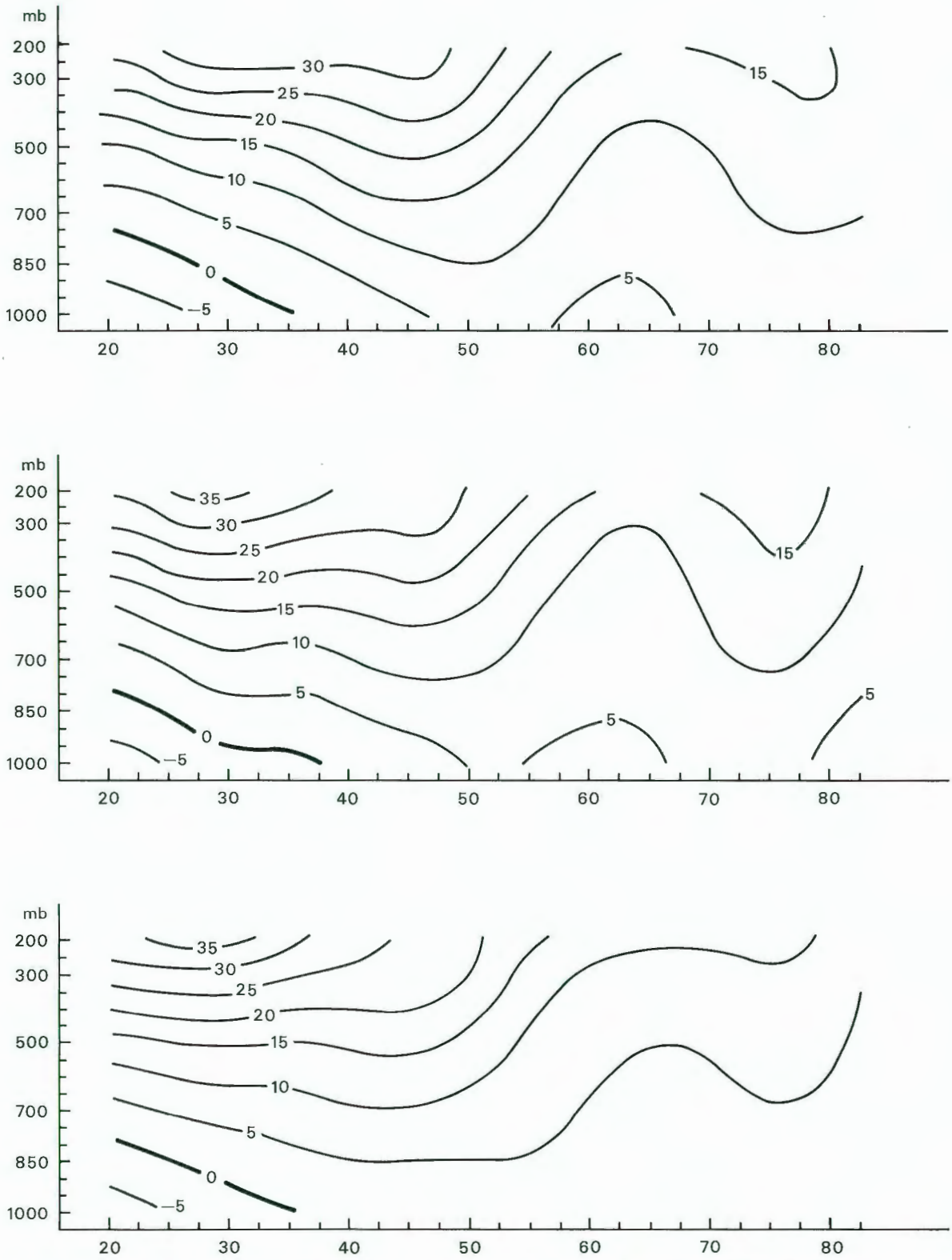


Figure 2 Latitude (Northern hemisphere) height distribution of the zonal mean of the zonal wind; average over days 5 to 10 of forecasts based on initial data for 00GMT 22/2/76. Original convection scheme (upper frame); revised convection scheme (centre frame); NMC analysis (lower frame).

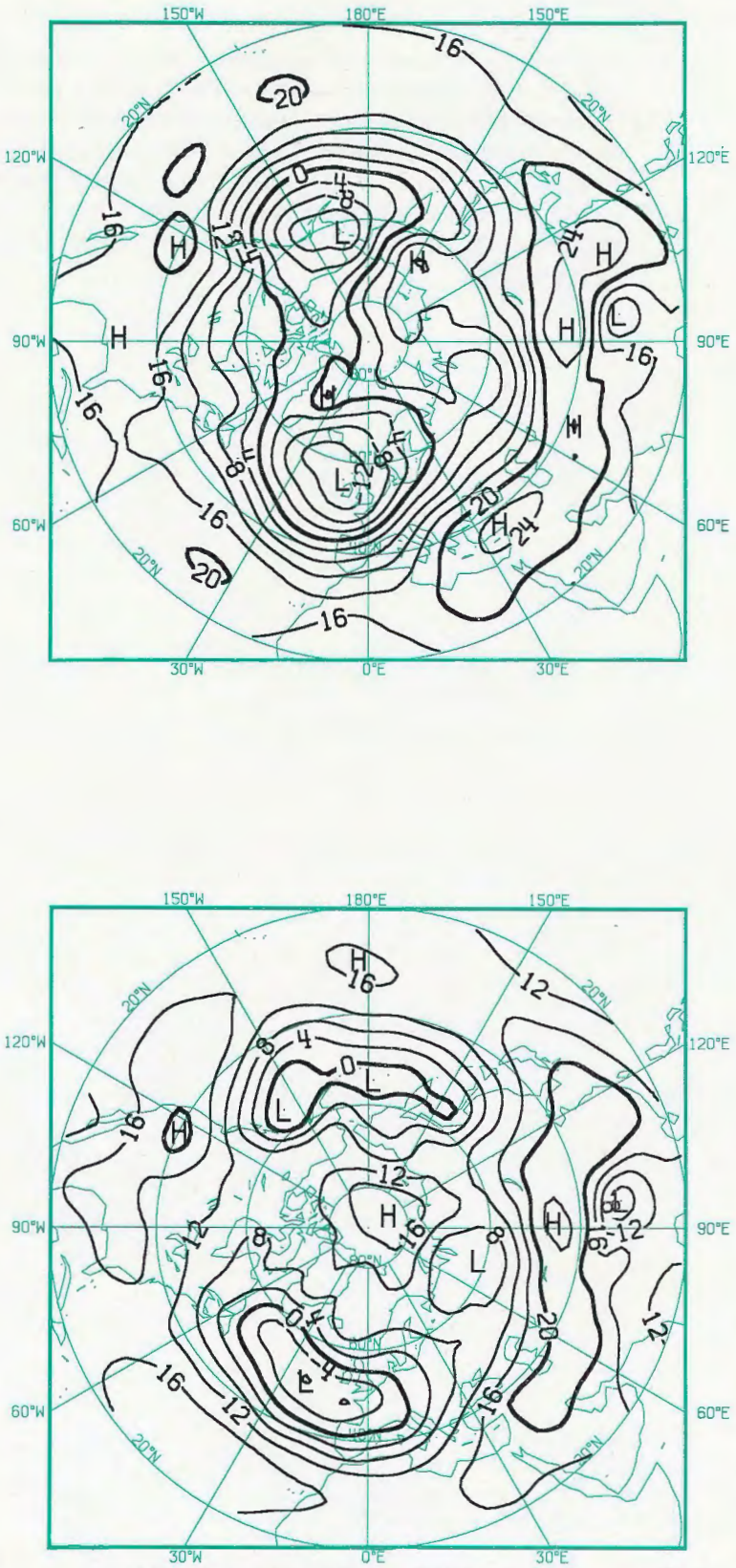


Figure 3 25 day means of 1000 mb heights (North of 20°N) from the last 25 days of two fifty day integrations. Original surface flux formulation (upper frame); revised surface flux formulation (lower frame).

FGGE Activities (First GARP Global Experiment)

All of the seconded scientists arrived by the autumn of 1979. The group has developed a great many diagnostic tools for monitoring the analyses. As a result they have uncovered many weaknesses in the analysis scheme which have been removed.

In February and again in April/May 1979 the FGGE End-to-End tests were carried through successfully. These were tests in near real time of the entire FGGE data processing organisation from the primary data producers to the final analyses. The production of the level II-b data sets was delayed by 4–5 months and so the production of FGGE analyses by the Centre could not begin until December 1979. Production is now progressing smoothly and by the end of the year 1 month of level II-b data have been analysed.

Operations Department

Structure and Responsibilities

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 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:

Computer Operations	–	Day to day operation of the computer system.
Operating Systems	–	Implementation, maintenance, development and support of the basic software (operating systems, compilers and utilities), of the computer complex.
Telecommunications and Graphics	–	All aspects of the communications facilities, the telecommunications network linking the Centre and the Member States, the implementation and support of the graphics system.
User Support	–	Assisting users in all aspects of use of the Centre's computing facilities and in programme development, maintenance of programme libraries, training and documentation.

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

Meteorological Applications	–	Implementation, maintenance and development of the meteorolological operational cycle required to sustain the daily production of medium-range forecasts in real time.
Meteorological Operations	–	Monitoring in real-time and longer term, the behaviour of the operational cycle from a meteorological point of view, including checks and correction of input observational data and assessment and verification of the forecast products.

Highlights

The outstanding achievement in 1979 has been the successful start of the first phase of operational medium-range weather forecasting at the Centre. Operational activity started on 1 August, and since then a forecast to 10 days has been carried out five times a week. Not one planned forecast was lost, although there have occasionally been delays of a few hours in forecast production, usually as a result of computer hardware problems.

Computing Facilities

The full configuration of the computing system at the Centre is shown in Figure 4. The computing complex basically comprises three levels – the

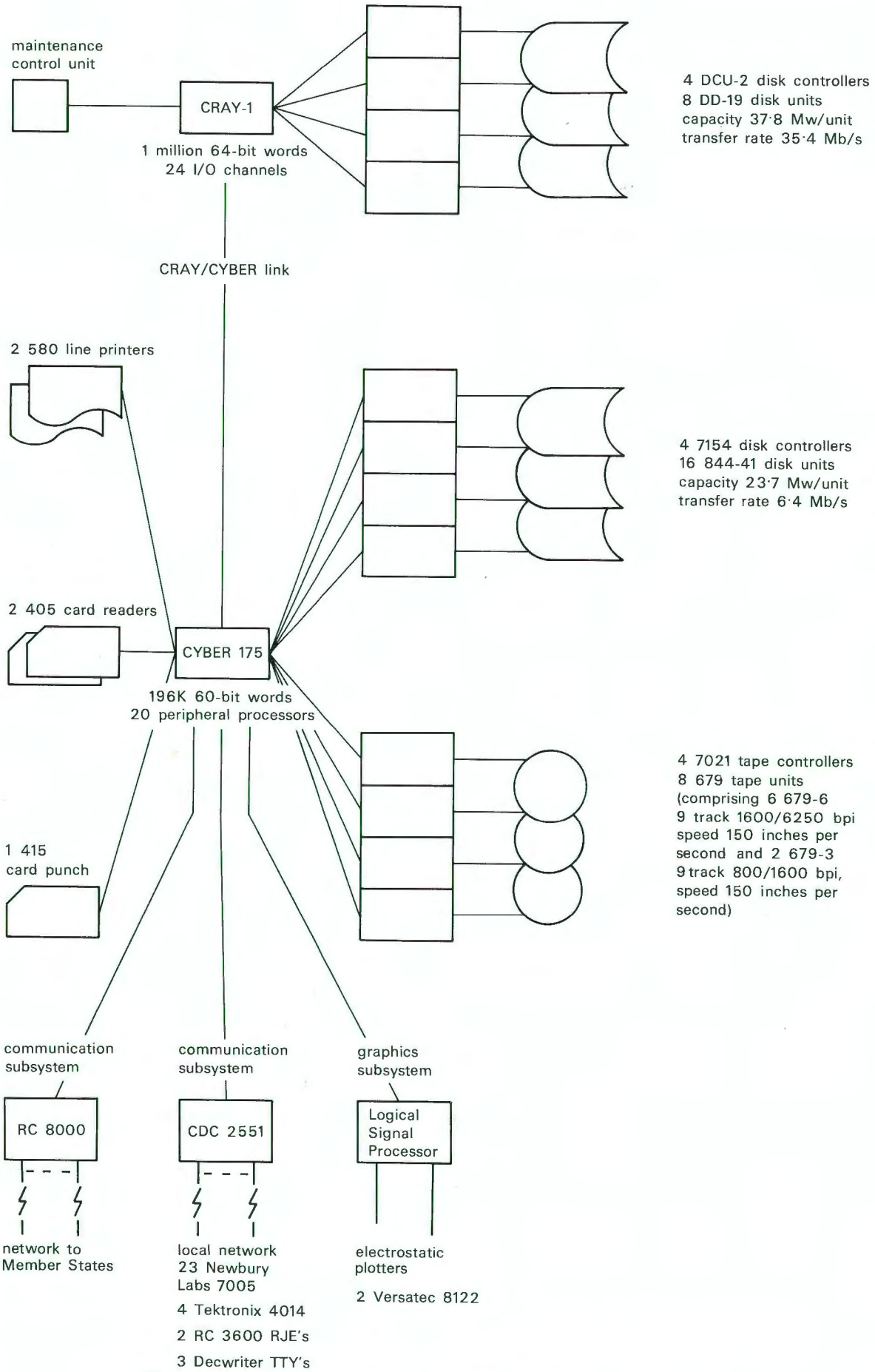


Figure 4 Configuration diagram of ECMWF Computer System.

CRAY-1 of Cray Research Inc., a powerful "number cruncher", front-ended by a CDC CYBER 175, which has a wider range of software facilities, to control the running of the operational forecast and other tasks, and this, in turn, front-ended by smaller computers to control communications locally as well as with Member States and graphical output. The CRAY-1 and CYBER 175 had been installed in the permanent headquarters of the Centre at the end of 1978 and provisionally accepted shortly thereafter. Following this, a full computer service seven days per week, 24 hours per day began. Based on this experience in service, the CRAY-1 passed final acceptance on 6 February of this year with an average availability of about 99%. The CYBER 175 passed final acceptance on 7 March with an average availability of around 98%. In December 1978, a service based on the linked CRAY-1 and CYBER 175 began operation on a trial basis. The full capabilities of the link between the two computers were gradually introduced over the following two month period and some additional improvements were made to bring performance closer to specification. The complete linked system, together with the link hardware and software were finally accepted, together with the CYBER 175 on 7 March. The link between the two computer systems plays an essential part in the overall configuration, greatly facilitating the submission of jobs to the CRAY-1 and transfer of data to and from the CYBER, and improving the turn-round of CRAY jobs.

Developments in the Computer System in 1979

During the year there were no changes or additions to the CRAY-1 hardware. Additional peripheral equipment was added to the CYBER 175 during the year, bringing the configuration up to the full 16 disk units and 4 disk controllers, 8 tape units and 4 tape controllers, which were initially planned. Connections between the CYBER and the telecommunications processor (see below) and the graphics subsystem were established. The link software has been steadily developed and improved throughout the year, and stability and throughput have increased substantially.

Computer Service and Statistics

Following their installation in late 1978 both computer mainframes have settled well, although the behaviour of the recently added CYBER peripherals is still not completely satisfactory. The workload on both machines has grown dramatically and during the second half of the year, especially following the start of operational activity, there has regularly been a back-log of work on the CRAY-1. By the end of the year, over 3000 jobs per week using 90 hours of central processor time were being run on the CRAY-1 (see Figure 5).

In total in 1979 111,000 jobs were run on the CRAY-1 using 3541 hours of central processor time. The average availability of the CRAY-1 was encouragingly high; there was a mean time between hardware faults of 94 hours, software faults of 119 hours (overall 52 hours), and a scheduled availability of 98.4%.

On the CYBER 175, the number of jobs being run by the end of the year had increased to nearly 12000 per week using 60 hours central processor time (see Figure 5). In total in 1979, 395,000 jobs were run using 2423 hours of central processor time. The overall scheduled availability was 98.5% with a mean time between hardware faults of 180 hours, software faults of 83 hours (overall 57 hours).

The mean time between failure of the link between the CYBER and CRAY-1 has remained at approximately ten hours throughout the year. Effectively, however, stability and reliability have increased steadily through the year as four times the number of files were being transferred at the end of the year compared with the start.

Who used the Computer Resources

The daily running of the operational suite accounted for a significant fraction of computer use in the second half of the year (34% of total). The batch service to Member States formally began on 1 July but access by Member States has been limited by the fact that no medium-speed communications have been available this year, apart from a connection to Sweden established in December. Therefore, there has been, except for Sweden, no remote usage but several Member States have used the Centre's computer system on site to a small extent. Member State utilisation in the second half of 1979 came to 6% of the total (see Table 1). Virtually all the rest of the computer time was consumed by the Research Department in the Centre in developing the analysis system and the FGGE project, and experiments with a variety of forecast models.

Table 1: CRAY-1 usage by Member States since 1 July 1979

Member State	Allocation (CRAY-1 CP hours)	Usage (CRAY-1 CP hours)
Belgium	—	—
Denmark	12	—
Germany	100	4
Spain	—	—
France	100	23
Greece	—	—
Ireland	3	0
Italy	70	0
Yugoslavia	—	—
Netherlands	12	5
Austria	10	0
Portugal	—	—
Switzerland	—	—
Finland	5	0
Sweden	6	7
Turkey	—	—
United Kingdom	175	76
Totals	493	115

Local Terminal Service

During the year additional visual display terminals have been delivered and put into operation; by the end of the year over 20 alphanumeric visual display units were in use and 4 graphical terminals (Tektronix 4014), one with a hard copy device. Several of the terminals have been placed in the offices of staff members.

There are also two remote job entry terminals (Regnecentralen 3600s) with card reader and line printer facilities.

Computer Operations Aspects

The computer service was operated throughout the year, 24 hours a day, 7 days a week, naturally requiring a shift system for operators to provide the necessary cover. Much progress has been made in all aspects of the total operational activity, including laying down standards for working with the various equipment in the Centre's computer complex and establishing procedures for CRAY-1 and CYBER control and the operational forecasting system.

Telecommunications

The external telecommunications network linking the Centre and Member States is controlled by hardware centred round a Regnecentralen 8000

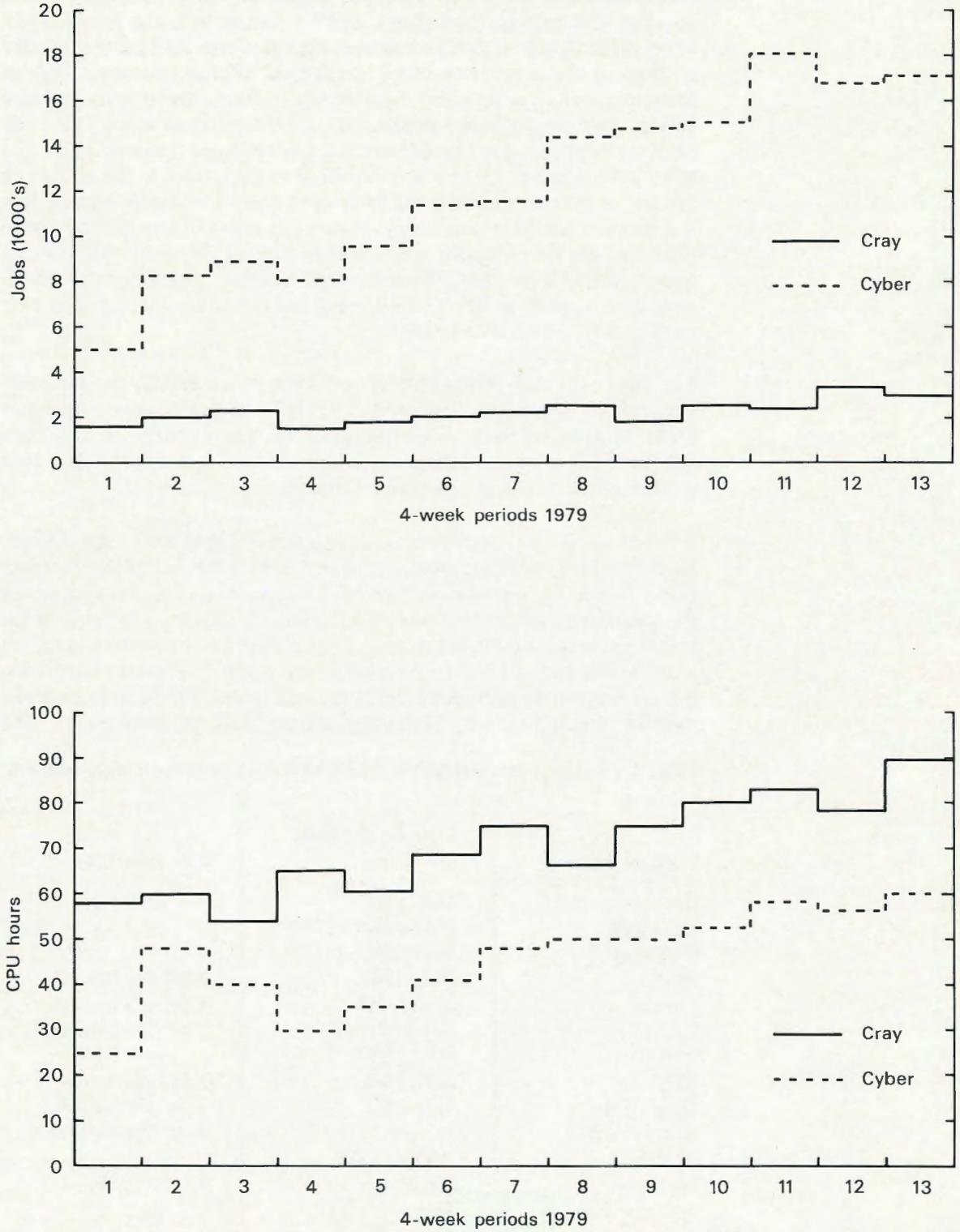


Figure 5 Average number of jobs per week (top diagram) and average CPU hours used per week (bottom diagram) for the CRAY-1 and CYBER within each 4 week period in 1979.

computer, and software developed under contract by Service in Informatics and Analysis Ltd. UK (SIA). The system is linked to the CYBER 175 and controls the communication lines to Member States using manufacturer independent communications protocols. The protocols that have been adopted were based on internationally recommended and approved standards where these were available. However, for some levels internal development has been necessary, but full liaison with the international effort in the field has been maintained. Facilities provided are the transfer of files for the acquisition of meteorological data and dissemination of forecast results via low and medium speed lines, and a remote batch service for Member States connected by medium speed lines. There has been major progress in this telecommunications project during 1979. The telecommunications system was delivered to the Centre in the first week of June. A number of low speed links were quickly available (during July and August) but there were delays in the connection of any medium speed lines and the first medium speed connection (to Sweden) only became operational in December. The telecommunications processor was provisionally accepted in late October and is now going through the nine months final acceptance phase.

The status of, and planned implementation schedule for, the telecommunications network linking the Centre and Member States is shown in Table 2. This schedule is as approved by The Council at its eighth session in November following recommendations made by the first session of the Technical Advisory Committee in September.

The low speed connections indicated in Table 2 (except to the Netherlands and Portugal) were operational well before the end of the year and being used to disseminate the Centre's forecast products in real-time. Of the medium speed connections only the link to Sweden was fully operational and being used to receive the Centre's products and for remote job entry by the end of 1979. Denmark, Germany and Sweden are participating in a project in which SIA have developed software for termination of a medium speed link with a Regnecentralen 3600 mini-computer. The

Table 2: Implementation schedule for ECMWF telecommunication network

Member State	Date for medium speed lines	Low speed line
Belgium	July 1981	—
Denmark	November 1979***	—
Germany	November 1979**	—
Spain	May 1981	Yes* (50 bauds)
France	March 1980	Yes* (50 bauds)
Greece	September 1980	Yes* (50 bauds)
Ireland	June 1980	—
Italy	July 1980	Yes* (50 bauds)
Yugoslavia	July 1981	Yes* (50 bauds)
Netherlands	October 1980	Yes** (100 bauds)
Austria	August 1980	—
Portugal	December 1980	Yes** (50 bauds)
Switzerland	January 1984	—
Finland	May 1980	—
Sweden	October 1979*	—
Turkey	January 1982	Yes* (50 bauds)
United Kingdom	March 1979**	—

* circuit installed and working at end of 1979.
** circuit installed.
*** circuit delayed to 1980.

Centre is also involved as it would be of interest to connect the Regnecentralen batch terminals to the telecommunications system. The software for Sweden was delivered in November.

Graphics

At the beginning of the year, graphical output at the Centre was still being provided by the Varian Statos plotter operating off-line. In January, one of the Versatec plotters and hardware and software for the on-line interface to the CYBER 175 (supplied under a contract placed in 1978) passed the initial acceptance test and the plotter went fully on-line in March. The second Versatec plotter was accepted at the end of the year and is now available as a standby for the first. The number of maps and plots produced with the extra load imposed by the operational activity had risen to approximately 6000 a week by the end of the year.

User Services

With the installation of the computer system at Shinfield taking place at the end of 1978, the availability of the linked systems and the various software upgrades during the year, there was a major requirement to advise computer users (Centre scientists and programmers and visitors from Member States) on all aspects of use of the computing facilities. An advisory and consulting service has been operated throughout the year to deal with user queries and problems. A number of computer programme libraries have been introduced or are being worked upon.

Much detailed documentation has been provided with users in the Centre and Member States in mind, including a 100 page Computer Bulletin – "Introductory Guide to the ECMWF Facilities"; many other "Computer Bulletins" have also been produced explaining various aspects of the computer system. An "ECMWF Technical Newsletter" was introduced in February superceding the "Computer Newsletter". The Technical Newsletter incorporates articles and information on both meteorological and computing subjects.

Implementation of Operational Forecasting

The excellent progress made in the development of the suite of meteorological programmes required to support the medium-range operational forecasting is manifest in the successful start of activity on 1 August and the reliable production of forecasts since that date.

By May the preparation and first phase of development of the various sub-systems making up the operational suite was largely complete (apart from archiving). The processes were then incorporated into the full operational system, running under the control of the supervisor, which automatically initiates tasks or sets of tasks as appropriate. Much testing and development work was necessary, culminating in the production of a series of current forecasts for the Centre's opening ceremony on 15 June. Following further improvements, the first phase of real-time operations began in August.

Despite the delay in availability of an operational medium speed connection to the United Kingdom Meteorological Office, the Centre was able to acquire the necessary input data for operational forecasting. Data in raw GTS format were copied to tape at the United Kingdom Meteorological Office at strategic times and transported by road to the Centre. Products have been made available to Member States either by dissemination of grid-point data over telecommunications links as available or by despatch of forecast charts for an Atlantic-European area by mail as soon as possible the morning after the forecast is produced. Although products are not available to Member States in a useful real-time way by the latter mechanism, at least the opportunity is provided for experience to be gained in seeing the Centre's forecasts on a regular basis.

Improved back-up and restart facilities have gradually been added to the operational suite which, by the end of the year, seemed well able to survive and recover from various computer and other failures.

A range of data is being archived for operational and research purposes. This includes all the observational data currently being obtained operationally. Analyses and forecasts made by the Centre are also archived in a compact spectral form. Generalised retrieval of data has not yet been fully developed but a comprehensive system for users to obtain information from the archives in a number of appropriate formats is well under development and will be available in early 1980.

The preparation of a series of technical documents "Meteorological Bulletins" describing the implementation of and facilities available in the Centre's meteorological operational system has begun. So far only "Meteorological Bulletins" describing aspects of the dissemination of products to Member States – formats of messages, codes, the set of available products and the defined standard areas have been prepared.

Monitoring the Operational Forecasts

Meteorological analysts within the Centre oversee the behaviour of the operational suite as it runs from a meteorological point of view, to check the realism and consistency of the analyses and forecasts. In addition the overall coverage and quality of input observational data are examined.

This work involves considerable use of the display systems for observational data and numerical products. Input data bulletins and reports which contain serious format errors and cannot be automatically decoded are manually corrected if possible and made available for the analysis scheme. Because of the very limited manpower resources, usually only vertical temperature soundings in data sparse areas of the globe can be corrected. Particular care is taken in examining the analysis produced by the operational system. The data rejected at this stage give a good indication of the quality and validity of the analysis.

As well as the real-time supervision of forecasts, much effort is devoted to studying the synoptic characteristics and shortcomings of the analysis and forecasting systems on a longer term basis. A number of problems have been noted and brought to the attention of the Research Department. Beyond this, assessments and reviews of the Centre's analyses and forecasts from a synoptic viewpoint on a monthly basis have begun. There has also been investigation of various methods of presentation of results to display effectively the potential meteorologically valuable part of the prediction in the later part of the forecast (e.g. mean charts for three or five day periods, attempts to show predicted areas of cyclonic activity).

A "conventional" verification system has also been developed, including calculation of correlation coefficients and standard deviations for the Centre's forecasts over various areas. An example of the figures obtained is included in the section "Assessment and Verification of the Centre's Forecasts".

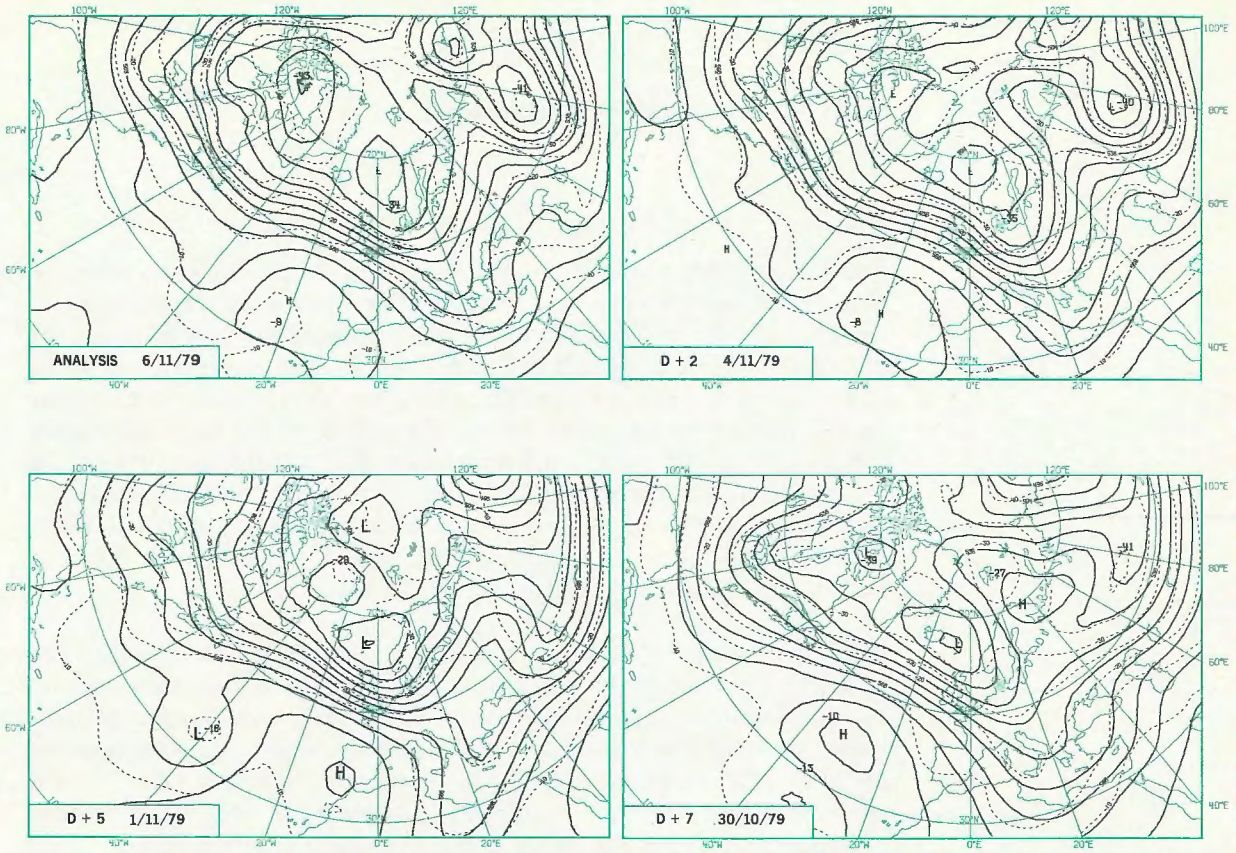


Figure 6 The Centre's 500 mb analysis over the Atlantic-European area for 12 GMT, 6 November 1979, and 2-day, 5-day and 7-day forecasts from previous days verifying at the time. 500 mb height contours (solid lines) are at 8 dkm intervals, and 500 mb temperature (dashed lines) at 5°K intervals.

Examples of Forecast

Figure 6 shows specific examples of the Centre's forecasts for various periods and the accompanying verifying analysis. The day 5 forecast from 1 November and day 7 forecast from 30 October (i.e. both verifying on 6 November) have most of the major features correctly predicted. The jet stream over the Atlantic and North-west Europe is in good agreement with the verifying analysis.

Assessment and Verification of the Centre's Forecasts

(Joint Research/Operations Department)

Staff of the Centre assess the quality of the Centre's forecasts and also prepare verification statistics. The overall impression of the standard of the forecasts in this first operational phase, also as reported by a number of forecasting offices in Member States, is that they are very good as far as three days and provide valuable guidance on the evolution of the larger scales out to, typically, five to six days. One of the most noticeable features of the first operational forecasts is the "adventurous nature" of the model, and its ability, on occasions, to forecast correctly rapid cyclogenesis. An obvious deficiency is a tendency for the model to overdevelop surface features and, in addition, to fail to describe the decay of cyclones in the last five days of the 10-day forecasts.

Preliminary study of five-day means of the model output for the later stages of the operational forecasts show indications that they contain useful information about departures from normal, even though the individual synoptic charts have lost useful skill. A particularly good forecast of the five-day mean anomaly of 500 mb heights, centred on day 7½ of a 10-day forecast, is illustrated in Figure 7. The use and information content of these mean charts will be the subject of research during 1980.

More specifically, Figure 8 gives the mean values of the correlation coefficients and standard deviations for the Centre's forecasts carried out in October, November, December over a European area for forecasts up to seven days ahead. Calculations of these values over the entire northern hemisphere give similar results.

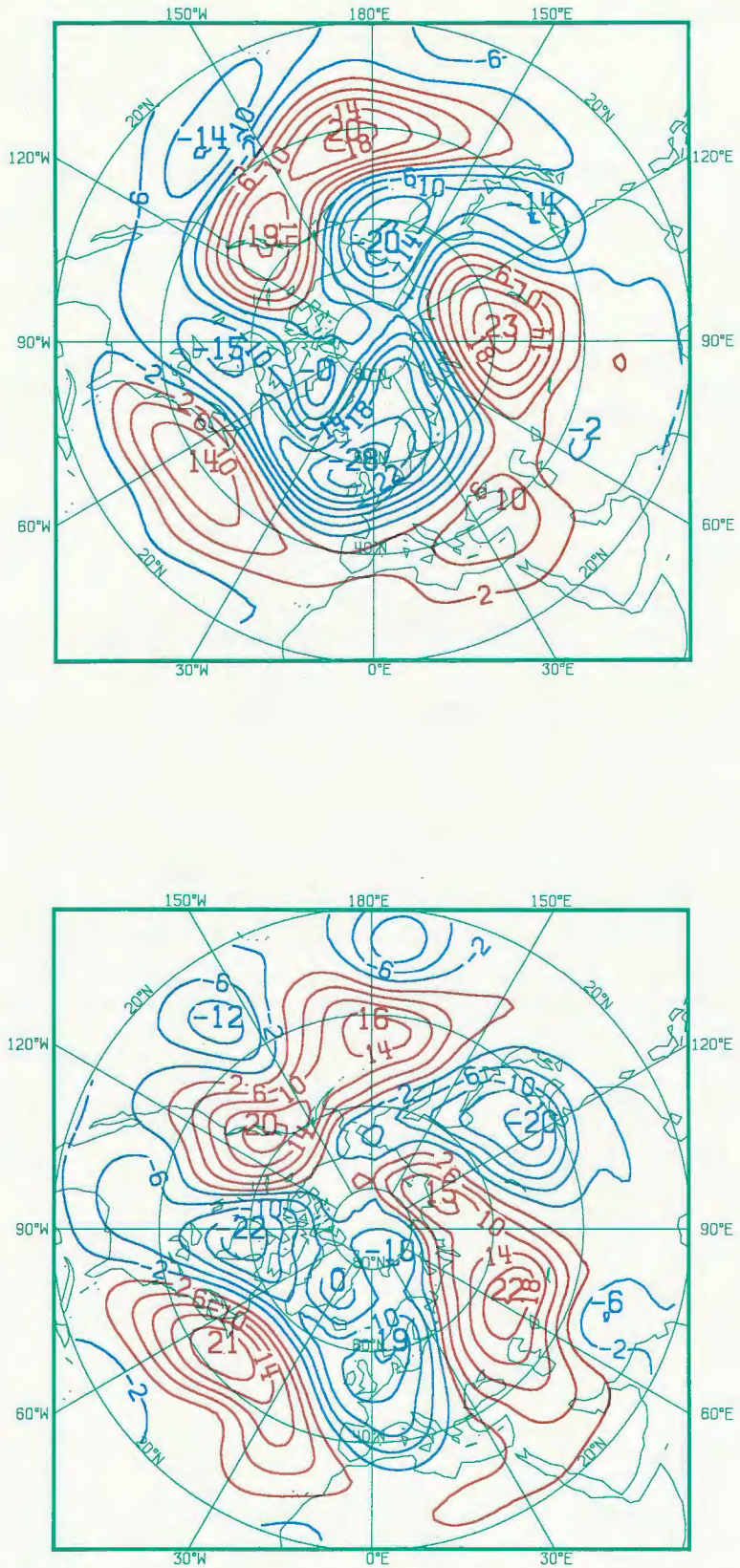


Figure 7 Means of 500 mb height anomalies from day 5 to day 10 commencing 5 November 1979. Forecast (upper frame); Analysis (lower frame).

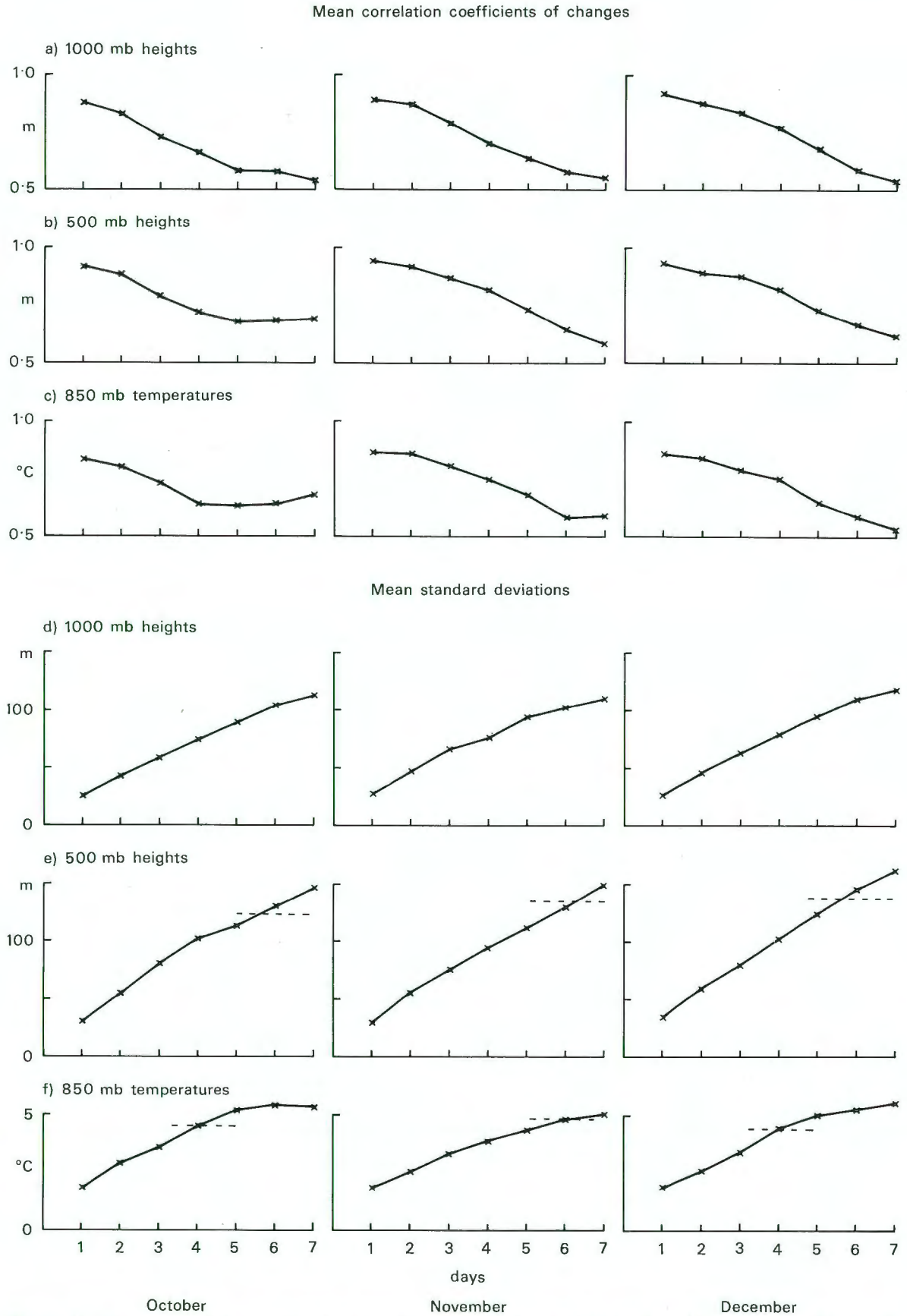


Figure 8 Mean correlation coefficients of changes and standard deviations (dashed lines climatological norm) of the Centre's forecasts for the European area.

Administration Department

Structure

The Administration Department of the Centre comprises four sections, i.e. Finance, Personnel, Supplies and General Services, and the Secretariat. The activities of these sections in 1979 included routine tasks and recruitment of additional staff.

Finance Section

In addition to the implementation of the Financial Regulations, preparation of the draft Budget 1980 and updated ceiling of expenditure estimates, the Section has been concerned in the course of 1979 with the acquisition of a mini-computer for the Centre's accounting system, negotiations on tax and excise questions (V.A.T., Import Duties), tender evaluations, and the follow-up of financial aspects of contracts, notably the contract for the lease-purchase of the Centre's computer system which has been concluded in early 1979.

Ceiling of Expenditure

At its 8th Session held on 21–22 November 1978, the Council adopted the new ceiling of expenditure for the years 1979, 1980, 1981 and 1982, and determined that the amount of the Member States' contributions to be paid during that period shall not exceed £22,884,000.

At its 10th session held on 7–8 November 1979, the Council updated this ceiling and decided that the ceiling of expenditure to be covered by the total of Member States' contributions for the years 1980–1983 shall not exceed £24,298,600.

For the years 1980, 1981 and 1982 the adopted ceiling of expenditure amounts to £20,430,050 with an increase of £1,489,650 (+7.86%) over the ceiling already approved by the Council for the same period. In terms of Member States' contributions the new ceiling for the same period 1980, 1981 and 1982 is increased by £801,000 (+4.64%) over the old one.

The increase in the estimated ceiling of expenditure and Member States' contributions is attributable for the largest part to inflation and salary increases. Price adjustments based on the estimated 1980 cost levels and increased amounts included for Centre-tax (which does not affect Member States' contributions) constitutes the remaining increase.

As in the past, computer costs and remuneration of staff are the largest part of the expenditure foreseen to implement the updated four-year programme of activities of the Centre.

It should be noted that due to a lease agreement between the Centre and Lombard North Central Leasing Limited, to cover the CRAY-1 system and mainframe CDC CYBER 170 Model 175, a saving of £500,000 per annum has been made. The total lease cost is £1.3 m per year.

Scale of Financial Contributions

The estimated Member States' contributions towards the 1979 Budget amounted to £5,611,600. These contributions were to be paid according to the Scale of Financial Contributions of the 17 Member States calculated on the basis of the Gross National Product (GNP), expressed in dollars, of each of the Member States for the years 1974, 1975 and 1976.

When approving the Budget for 1979, the Council decided that an amount of £96,100 related to blocked expenditure of the Budget should be ex-

Signature of the contract with Lombard North Centre Limited for the lease of the CRAY-1 and the CDC CYBER 170 Model 175 mainframe: Mr. C. Wilkinson, Lombard; Mr. B. Regan, Lombard; Dr. P. D'Ingeo, ECMWF; Mr. Adams, Lombard; and Dr. A.C. Wiin-Nielsen, ECMWF.

cluded from contributions to be paid by the Member States to the Centre's Budget.

The outstanding contributions of the previous years expected to be received during the 1979 financial year amounted to £194,326.63; at the end of the 1979 financial year, 3 out of 17 Member States party to the Convention had not paid their contribution.

Budget

The Budget 1979 of the Centre was adopted by the Council at its eighth session held on 21–22 November 1978. The approved total amount of the expenditure and revenue for the year 1979 was £6,162,600 with an increase of 15.22% over the estimated totals of the 1978 Budget of the Centre. The increase of the expenditure over the Budget of the previous year was inter alia due to the adjustment in the remuneration and recruitment of the new Staff Members, higher costs for the use and maintenance of the final configuration of the computer system, and the inflationary process reflected in the appropriations of the operating expenditure. 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. refund of taxes and bank interest.

During 1979, the financial needs of the Centre were mainly related to the operating expenditure of which the appropriation for the remuneration of the staff and the computer costs constituted the larger part of the Budget.

The estimated investment expenditure in 1979 covered mainly the cost of the purchase of the telecommunications system and additional technical equipment for the computer system. The estimated commitment appropriation of the Budget 1979 included the estimated cost for a five year lease agreement for the acquisition of the Centre's computer system.

Details of the estimated figures of the Budget 1979 which take into account transfers of funds authorised up to 31 December 1979 are tabulated below:

	Revenue	Expenditure	
		Commitment Appropr.	Payment Appropr.
Title I – Revenue	6,162,600		
Title II – Investment expenditure		64,200	513,800
Title III – Operating expenditure		6,947,100	5,648,800
Totals	6,162,600	7,011,300	6,162,600

Supplies and General Services

The Supplies and General Services Section has in the course of the first half of 1979 continued to accept both buildings and grounds of the permanent headquarters building at Shinfield Park, Reading. In particular handover of the Conference Block took place, a task accompanied at the same time by the installation of equipment, interpretation facilities, furniture and fittings, etc. All this was accomplished with a very tight schedule in order to be ready for the official opening ceremony of the Centre by HRH The Prince of Wales, KG, KT, PC, GCB on 15 June 1979.

The organisation and arrangements for this event were handled by this Section.

The Print Room facilities have expanded greatly along with the output of the Centre's documents. Over 1,200 jobs have been processed by the Print Room's two-man staff, ranging from a 1-page document with 100 copies to 500 copies of a 420-page document. With the acquisition of new equipment, it is expected that the high output of 1979 will be increased still further in 1980.

Maintenance, restaurant, alterations to buildings were all co-ordinated by this Section.

A market survey/cost effective study has commenced in order to assess whether there are any contractors who would be prepared to undertake some of the Centre's tasks which are presently individually contracted out. This survey is expected to be completed in the early part of 1980.

The Restaurant: designed to take 100 people at any one sitting.

The Concourse: situated between the Conference Room and Lecture Theatre, comprising of cloakroom/coffee bar.

The Council Meeting Room: the oval table seats 44 delegates plus 40 advisers' seats. The tapestry on the far panelling is a gift to the Centre from the Netherlands.

Library

At the end of 1979 the number of volumes in the library exceeded 2,500. The Centre also subscribes to about 96 journals, and receives others through an exchange scheme with libraries of Member States as well as with the Scientific Institutes of non-member countries.

Personnel Section

The section has continued with its task of implementation of staff legislation, general staff management, payment of salaries, allowances and expenses incurred on duty, and recruitment. It also tries to facilitate the arrival of new staff members and their families, in particular with regard to housing and education.

Staffing

The table of staff requirements for 1979 contained 144 posts. By 31 December 1979, there were 139 staff members and 10 visiting scientists at the Centre, leaving 5 vacant posts at the end of the year. For one of these vacancies the Centre was unable to recruit a suitable candidate from the Centre's Member States and therefore a visiting scientist was invited to carry out the tasks of this post. For a further two vacancies it was decided not to fill these positions and the Centre is proposing to delete these two positions in the table of staff requirements for 1980.

The Centre has been able, in recruiting new staff, to improve the balance of geographical distribution among the staff and these efforts will continue for the next few years. By 31 December 1979 nationals of 14 Member States were represented among the Centre's staff (see Annex 1 for details of the staffing at 31 December 1979).

European School

The new European School which started in September 1978 in Culham (near Oxford) has given great satisfaction as to the type and standard of education. The Headmaster of the school has continued his policy in accepting children of the Centre and by 31 December 1979, 17 of these children were attending the European School, and it is expected that this number will increase still further.

Medical Health Insurance and Social Security

The subject of a medical insurance additional to the National Health Scheme of the host country, the exemption from compulsory contributions to the United Kingdom Social Security Scheme for United Kingdom nationals and an additional insurance for the protection of staff members in cases of partial invalidity, as mentioned in earlier annual reports of the Centre, have received much attention throughout the year with much involvement of the staff members. It is hoped that in 1980 a satisfactory agreement can be reached with the United Kingdom authorities with respect to the exemption of compulsory social security contributions and also that the Council will be able to approve a scheme, additional to the Centre's Pension Scheme, to protect a staff member who is on sick leave at the expiry date of his fixed-term contract.

Co-ordinated Organisations

The Council expressed its concern that the Centre has not yet been admitted to the Co-ordinated Organisations due to opposition from NATO and OECD.

It instructed the Director to restart negotiations with a view to obtaining favourable consideration from the Councils of the aforementioned.

Secretariat

The Administration Department provided secretarial assistance at the two sessions of the Council and the four sessions of the Finance Committee. The Linguists section produced documentation in the working languages of the Centre for the Council and Finance Committee in addition to translations of scientific reports and other texts.

Education

Seminar

In September, the Research Department organised the Centre's annual seminar, this year entitled "Dynamical Meteorology and Numerical Weather Prediction". The invited lecturers were Dr. B. Hoskins, University of Reading, U.K.; Dr. P.G. Drazin, University of Bristol, U.K.; Dr. J. Derome, McGill University, Canada; Dr. M.E. McIntyre, University of Cambridge, U.K.; Dr. R. Sadourny, Laboratoire Meteorologie Dynamique, ENS, France.

The subjects covered were baroclinic instability; dispersive waves; forced planetary waves; wave-mean flow interaction; conservation laws for large scale atmospheric flow; non-linear systems; numerical modelling; orographic forcing in numerical models; theories of blocking.

Meteorological Training Course

The Research Department at the Centre arranged its first training course for meteorologists from the Member States, to take place from 8 May to 27 July 1979. The accompanying Lecture Notes were published in November 1979 and distributed to the Member States.

Computer Training Courses

The Operations Department arranged a series of computer training courses which were given to staff from Member States and internal Centre staff. They were:

Introduction to ECMWF's computer facilities	17 April
Basic use of ECMWF computer facilities	18–20 April and 17–21 September
CRAY usage	23–27 April and 24–28 September
CYBER usage	1–5 October

The total number of attendees (often to more than one of the courses) was 44 from 12 different Member States and 12 Centre staff. A one week CYBER/CRAY training course was also given as part of the three month Research Department training programme.

Research Department Workshops

"The Incorporation of Mountains in Numerical Models of the Atmosphere"
This was organised with the two-fold purpose of assessing the present state of knowledge on some topics of direct relevance to the Centre's objectives and to generate discussion about possible areas of future research. Experts were invited from Germany, Yugoslavia, the Netherlands, Norway, Sweden, United Kingdom and the United States of America. Several staff members of ECMWF participated in the workshop which comprised ten lectures given by invited speakers and discussion sessions during which reports on five main topics were produced. These five topics were analysis and initialisation; representation of orography in numerical models; mountains and long-wave numerical prediction; synoptic scale numerical prediction; the parameterization of sub-grid-scale mountain induced processes.

The proceedings of this workshop have been distributed.

"Stochastic Dynamic Forecasting"
The purpose of this workshop was to exchange information in the area of stochastic forecasting and to outline, as far as possible, the avenues of research that the Centre might pursue.

The programme concentrated on two main fields, namely Monte-Carlo forecasting with large scale numerical weather prediction models and Stochastic forecasting with simple models.

Experts from Germany, United Kingdom, and the United States of America were invited.

The proceedings of this workshop are being prepared and will be distributed early in 1980.

Operations Department Workshop

"ECMWF Future Graphical System"

The purpose of the workshop was to assess the present state of knowledge on aspects of design of a graphic system for meteorology including hardware and software considerations, standards for graphics, device independence and the use of computer graphics for meteorological applications. At the Centre at present all the calculations to produce graphical output are performed on the CYBER 175 constituting a significant use of computer resources. The wider range of facilities required and amount of information to be put into graphical form necessitates investigation of a device independent distributed system driving a variety of devices. The workshop provided the main considerations to be borne in mind when designing such a future graphical system. Experts from France, Finland and the United States of America participated together with a number of Centre staff members. The proceedings of the workshop have been distributed.

Visiting Scientists

During 1979, the Operations and Research Departments had the following visiting scientists.

Operations Department:

Mr. Colvill, University of London Computer Centre, United Kingdom.

Mr. S. Jay, University of Arizona, United States of America.

Mr. H.J. Kirschner, Deutscher Wetterdienst, Offenbach, Germany.

Mr. J.W. Larsen, Danish Meteorological Institute, Copenhagen, Denmark.

Mr. J. Lepas, Meteorologique Nationale, Paris, France.

Dr. D. Robertson, Recherche en Prevision Numerique, Atmospheric Environment Service, Canada.
Dr. H. Schwetman, University of Purdue, United States of America.

Dr. D. Söderman, Finnish Meteorological Institute, Helsinki, Finland.

Research Department:

Mr. K. Bjørheim, Meteorological Institute, Oslo, Norway.*

Dr. J. Derome, McGill University, Dept. of Meteorology, Montreal, Canada.

Dr. C. Girard, Atmospheric Environment, Montreal, Canada.

Dr. Karl Johannessen, National Weather Service, Silver Spring, Md., United States of America.

Dr. P. Julian, National Center for Atmospheric Research, Boulder, Colorado, United States of America.*

Dr. M. Kanamitsu, Electronic Computing Center, Japan Meteorological Agency, Tokyo, Japan.*

Dr. G. Kontarev, Computing Center, Akademgorodók, Novosibirsk, Union of the Soviet Socialist Republics.

Dr. V. Lykossov, Computing Centre, Akademgorodók, Novosibirsk, Union of the Soviet Socialist Republics.

Dr. H. Økland, Universitetet i Oslo, Institute for geofysikk, Oslo, Norway.

Mr. P. Price, Bureau of Meteorology, Melbourne, Australia.*

Mr. M. S. Tracton, National Meteorological Center, Washington, United States of America.*
* On secondment.

The Council and its Committees

Council Sessions

In 1979, two sessions of the Council were held, on 13–14 June and 7–8 November respectively. The June session immediately preceded the official opening of the Centre on 15 June by HRH Prince Charles.

Elections

At its 10th session held in November 1979, the Council unanimously elected Dr. P.K. Rohan (Ireland) as its President and Professor E. Lingelbach, (Germany, Federal Republic of), as its Vice-President, for a one-year term in each case.

The Council expressed its sincere thanks to Dr. A. Wiin-Nielsen for the excellent work he has accomplished at the Centre, and congratulated him on his election as Secretary General of the World Meteorological Organisation.

Mr. Labrousse was welcomed by the Council as successor to Dr. Wiin-Nielsen as Director of the Centre as from 1 January 1980.

Finance Committee

Four sessions of the Finance Committee took place in 1979, on 16–18 January, 11–12 April, 16–18 July, and 18–20 September respectively.

Elections

At the 10th session of the Council, it was noted that the delegates of Ireland, the Netherlands, and Yugoslavia to the Finance Committee, whose terms of office expired at that time, were replaced by delegates from Sweden, Belgium and Portugal.

Scientific Advisory Committee

One session of the Scientific Advisory Committee was held during 1979, on 18–19 June. The Committee congratulated the Centre on the production of its first real-time forecast, and endorsed its programme of activities for the next four years.

Technical Advisory Committee

The first session of the Technical Advisory Committee was held on 4–6 September 1979. All Member States participate in the work of this new Committee (see Annex 5 for membership), which, in addition to other tasks, takes over the duties of the Advisory Committee on matters relating to communication between ECMWF and the Member States. The Technical Advisory Committee, inter alia, reviewed the plans for the telecommunications network between the Centre and the Member States, and advised on the technical aspects of the Centre's Budget and programme of activities for the years 1980–1983. The recommendations made by the Committee at its first session were approved by the Council in November. At the same Council session, it was determined that the Technical Advisory Committee should be responsible for monitoring the production, transmission and use of the operational products of the Centre, monitoring the implementation of the operational systems, and assessment of the fitness of the products for operational use.

Staff Committee

In 1979 the Staff Committee continued its function of representing the professional interest of the staff. Through regular meetings with the Director and the Head of Personnel, as well as through regular contacts with the management of the Centre, the Staff Committee presented the view of the staff and played an important role in the life of the Centre.

Among the many problems in which the Staff Committee was involved, a few particularly stand out. The question of the policy regarding renewal of contracts was an important one. Some of the ideas of the staff were included in the Director's report to the Council on the subject. Another problem was that of the Social Security contributions by UK staff members, a problem which is not yet solved. The question of shift systems and of overtime also occupied much of the Staff Committee's attention.

In October the annual general meeting of staff was held. Rules of procedures for the Staff Association were adopted and the review of the Administration Department, which had been conducted by a group established by the Council, was discussed.

Not everything is serious argument however. In 1979 the Social Committee was revived, after a lull of about a year. Among other activities a Halloween party and a Christmas dance were both great successes. This year also saw the birth of the ECMWF Film Club which has shown classic movies every other week in the excellent facilities of the Centre.

On the international scene, the Staff Committee has continued to attend the meetings of the Standing Committee of Staff Associations of the Co-ordinated Organisations (CPAPOC), thanks to voluntary contributions by the staff for the travels of the committee representatives. In December the CPAPOC agreed to change the status of the ECMWF Staff Committee from observer to full member, so that the ECMWF staff is now truly represented in the negotiations with the Co-ordinating Committee, concerning salary, allowances, pension scheme, etc.

Annex 1

Staff at 31 December 1979

Director	A.C. Wiin-Nielsen	Denmark
Head of Research Department	L.O. Bengtsson	Sweden
Head of Operations Department	J. Labrousse	France
Head of Administration Department	W.D. von Noorden	Germany

Distribution of staff by grade and nation

	Grade					
	h.g.*	**A**	**B**	**C**	**L**	**Total**
Belgium		2				2
Denmark	1	2				3
Germany		11	4		1	16
Spain		1				1
France		10	3		1	14
Greece						
Ireland		4	1			5
Italy		5	2			7
Yugoslavia		1	1			2
Netherlands		3	3			6
Austria		2	1			3
Portugal						
Switzerland						
Finland		4				4
Sweden		4				4
Turkey		1				1
United Kingdom		26	39	6		71
Totals	1	76	54	6	2	139

* Hors grade

10 visiting scientists were also employed by ECMWF at 31 December 1979.

Annex 2

Members of the Council

President	L.A. Vuorela	Finland
Vice-President	R. Mittner	France
	R. Sneyers	Belgium
	M. Deloz	Belgium
	O. Nielsen	Denmark
	L.B. Asmussen	Denmark
	E. Lingelbach	Germany, Federal Republic of
	H.G. Schulze	German, Federal Republic of
	A. Gonzales-Rivero	Spain
	M.A. Martin-Sané	France
	A. Bassiakos	Greece
	P.K. Rohan	Ireland
	L. Zancla	Italy
	M. Mariani	Italy
	D. Radinovič	Yugoslavia
	A. Lambasa	Yugoslavia
	H.C. Bijvoet	The Netherlands
	T.B. Voerman	The Netherlands
	K. Cehak	Austria
	L.A. Mendes-Victor	Portugal
	G. Simmen	Switzerland
	D. Söderman	Finland
	L. Ag	Sweden
	O. Lönnqvist	Sweden
	Director General	Turkey
	B.J. Mason	United Kingdom
	C.P. Lynam	United Kingdom
	R. Schneider	W.M.O. Observer

Annex 3

Finance Committee

Chairman: Mr. P.P. Wrany (Germany, Federal Republic of)
Vice-Chairman: Mr. H. Fontijn (The Netherlands)

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 1979 the Committee was composed as follows:

i) *Those paying the largest contributions:*

Germany, Federal Republic of
France
Italy
United Kingdom

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

Ireland
Yugoslavia
The Netherlands

At its 10th session held in November 1979 the Council took note that on the expiry of their term of office, these last three would be replaced by Belgium, Portugal and Sweden.

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.R. Bates	Ireland
Vice-Chairman:	F. Mesinger	Yugoslavia
	F.H. Bushby	United Kingdom
	B. Döös	Sweden (and WMO representative)
	E. Eliasen	Denmark
	K. Hasselmann	Germany, Federal Republic of
	E. Holopainen	Finland
	J. van Isacker	Belgium
	P. Morel	France
	S. Palmieri	Italy
	H. Reiser	Germany, Federal Republic of
	C. Schuurmans	The Netherlands

At its November session the Council appointed Dr. R. Sadourny (France) and Dr. H. Sundqvist (Sweden), to fill the places vacated by Dr. B. Döös and Dr. P. Morel at the end of their term of office. It expressed the hope that Dr. Döös would continue to participate in the work of the Committee as the representative of WMO.

Annex 5

Members of the Technical Advisory Committee

All Member States are members of the Technical Advisory Committee. The representatives of each Member State in 1979 were:

Chairman:	D. Söderman	Finland
Vice-Chairman:	J. Lepas	France
	G. Wihl	Austria
	W. Struylaert	Belgium
	E. Busch	Denmark
	W. Buschner	Germany, Federal Republic of
	G. Barbournakis	Greece
	W.H. Wann	Ireland
	G. de Florio	Italy
	P. Kastelein	The Netherlands
	S. Cristina	Portugal
	B. Orfila	Spain
	L. Moen	Sweden
	M. Haug	Switzerland
	Director General	Turkey
	R. Wiley	United Kingdom
	Z. Butigan	Yugoslavia

The Committee elected D. Söderman (Finland) as Chairman and J. Lepas (France) as Vice-Chairman at the session of the Committee in September.

Annex 6

International Meetings attended and visits made by Members of Staff

1979		
18–21 January	Lecture on Vector Processing to Shell Research Symposium, Rijswijk	J. K. Gibson
29 January – 2 February	Informal Planning Meeting on integrated observing system over ocean. Geneva	L. Bengtsson
6–9 February	WGNE Meeting of JOC, Cambridge University, Cambridge	L. Bengtsson
12–16 February	Cyber Record Manager Analysis course and visit to Deutscher Wetterdienst, Frankfurt	M. Miqueu
12–16 February	Flow Control Symposium and International Networks Working Group, Paris	P. Quoilin
12–16 February	World Climate Conference, Geneva	A. Wiin-Nielsen
19–20 February	Visit to Institut Royal Meteorologique de Belgique, Brussels	J. Labrousse
26 February– 4 March	JOC Meeting, Dubrovnik	L. Bengtsson A. Wiin-Nielsen
19–20 March	Workshop on Planetary Boundary Layer Modelling, Florence	J.-F. Louis
19–23 March	ECODU 27 Conference, London	R. Brinkhuysen P. Gray F. Hollmann F. Königshofer T. Stanford
22 March	ESA – Steering Committee, Paris	L. Bengtsson
25–28 March	Visit to WMO for telecommunications discussions, Geneva	J. Labrousse
30 March–13 April	Visit to ODSI, Monterey, NCAR, Boulder and NMC, Washington to assess meteorological graphical applications	A. Lemaire
1–3 April	FGGE Working Group on Data Management – III, Paris	P. Kållberg
2–6 April	Euromech Conference on "Flow over Mountains", Trautheim	H. Pümpel S. Tibaldi
25 April–12 May	Visit to CRI and CDC for meetings and investigation of future facilities, San Francisco, Phoenix, Minneapolis, USA	R. Brinkhuysen P. Gray
1–8 May	WMO Congress, Geneva	A. Wiin-Nielsen
11–15 May	Discussion and lecture at KNMI, De Bilt	A. Hollingsworth

15–19 May	WMO Congress, Geneva	A. Wiin-Nielsen
28 May–2 June	WMO Executive Committee, Geneva	A. Wiin-Nielsen
6–8 June	ECODU, Directors Meeting, The Hague	R. Brinkhuysen
10–16 June	Teleinformatique Conference IFIP TCG meeting, Paris	F. Königshofer
13–16 June	ECODU, Interim ECCOS Meeting, Geneva	T. Stanford
5 July	Conference on conjugate gradient methods and similar techniques, Harwell	J.K. Gibson C. Temperton
5–8 July	Meeting at Laboratoire de Meteorologie Dynamique, Paris to discuss modelling work	E. Källén
9–13 July	Stanstead Seminar, Montreal	K. Arpe L. Bengtsson
4–18 August	SIGGRAPH Conference, Chicago. Visits to various sites in USA to check graphics developments	H. Watkins
5–16 September	Visit to Meteorological Centres, China	A. Wiin-Nielsen
12–14 September	EGS meeting, Vienna	S. Tibaldi
17–21 September	Technical Conference on the use of data from Meteorological Satellites, Lannion	L. Bengtsson
23–28 September	ECODU 28 Conference, The Hague	R. Brinkhuysen A. Lea T. Stanford
23 September– 4 October	Visit to Canadian Meteorological Service, Montreal, NCAR, Boulder, and NMC Washington	J. Martellet
7–12 October	CBS Informal Planning Meeting on Integrated WWW System Study. Geneva (as JOC Representative)	L. Bengtsson R. Newson
7–13 October	Meeting on Use of Centre's Limited Area Models by Member States to: SMHI, Norrköping and Met. Institute, Copenhagen	D. Burridge
8–12 October	Visits to sites with CRAY-1 computers in USA (Boulder, Kansas, Minneapolis, New Jersey)	N. Storer
15–17 October	Visits to SMHI, Norrköping	B. Norris
15–19 October	VIM Conference, Detroit	E. Walton N. Storer
21–27 October	RAVI Working Group on Telecommunications, Geneva	J. Hennessy
22–25 October	Meeting of Working Group on Data Management for FGGE, Norrköping	P. Kållberg

23–25 October	Cray User Group, Shinfield Park (hosted by ECMWF)	P. Gray R. Dixon N. Storer G. Harding A. Lea D. Dent J. Greenaway P. Prior L. Bertuzzi D. Burridge J.K. Gibson G. Holt
23–28 October	Visit to IRIA, Paris and EUROGRAPHICS 79 Conference, Bologna	A. Lemaire
29 October	Lecture at Techn. University, Zurich	A. Wiin-Nielsen
19 October– 2 November	Visits to Gandolf, Ottawa, CDC Minneapolis and Computer Peripherals Inc., Philadelphia	E. Walton
23 October– 2 November	4th Conference on NWP, Washington, Study visits to GFDL, Princeton and NMC, Washington	M. Jarraud
24 October– 7 November	4th Conference on NWP, Washington and consultation on US "Special Effort – FGGE"	M.S. Tracton
28 October– 1 November	Discussion at French Met. Service, Paris	J.-F. Geleyn
29 October– 2 November	Fourth Conference on Numerical Weather Prediction, Silver Spring, Maryland	A. Woods
5–6 November	Visit to Canadian Meteorological Service, Montreal	A. Woods
7–9 November	Discussion at Cologne University	J.-F. Geleyn
11–16 November	7th Session of WMO Executive Committee Intergovernmental Panel of the FGGE, Geneva	L. Bengtsson
11–16 November	CHARM Workshop, Ajaccio	A. Wiin-Nielsen P. Kållberg
15–24 November	ALPEX Working Group, Vienna	S. Tibaldi
25–27 November	Control Data Institute Structured Analysis Seminar and visit for 1 day to Danish Meteorological Institute, Copenhagen	C. Guillerand
25–30 November	ACM Data Communications Meetings and International Network Working Group Meeting, Pacific Grove, California	P. Quoilin
24 November– 1 December	JOC Officers Meeting, Wellington	A. Wiin-Nielsen
2–4 December	Conference on communications in distributed systems, Berlin	A. Haag
3–11 December	IUGG Meeting, Canberra	A. Wiin-Nielsen

5–7 December	Discussion at Deutscher Wetterdienst, Offenbach	M. Tiedtke
6–7 December	ECODU Executive Meeting, Geneva	J. Labrousse
7–8 December	ECODU Interim ECCOS Meeting, Geneva	T. Stanford
10–12 December	Lecture on mid-latitude disturbances at University of Köln	H. Böttger
10–20 December	GARP Symposium, Melbourne, WGNE Meeting, Discussion of Research Cooperation with ANMRC Melbourne	L. Bengtsson
13–14 December	ECODU, Telecommunications Meeting, Munich	F. Königshofer

Annex 7

Publications by Members of Staff

Arpe, K. "Mittelfristige Wettervorhersagen mit Zirkulationsmodellen". *Promet* 2/3 1979, 43–44.

Arpe, K. "The impact of uncertainty of analysis data on verification and energetics studies".
In: *Stanstead Seminar Proceedings*, November 1979.

Bengtsson, L. "Numerical prediction of blocking".
In: *Stanstead Seminar Proceedings*, November 1979.

Bengtsson, L. "Problems of using satellite information in numerical weather prediction".
In: Technical Conference on "*Use of Data from Meteorological Satellites*", Lannion, France, 17–21 September 79 (ESA SP–143, October 79).

Bengtsson, L., Temperton, C. "Difference approximation to quasi-geostropic models".
GARP Publication Series *No. 17*, Vol. II.

Bengtsson, L. "On the use of a time sequence of surface pressure observation in 4-dimensional data assimilation".
(Accepted for publication in *Tellus*.)

Bengtsson, L. "ECMWF Global Forecasting System".
Atmospheric models for FGGE, to be included in
GARP Publication Series.

Burridge, D.M., Wiin-Nielsen, A. "Atmospheric Prediction Models".
Europhysics News 1979.

Gray, P. (with P. Lowell) "Cyber station software for the CRAY-1"
ECODU 27 Conference Proceedings, 19–23 March, pp. 97–105.

Hollman, F. "User experience with ATS".
ECODU 27 Conference Proceedings, 19–23 March, pp. 128–133.

Königshofer, F. "Open Network Architecture at ECMWF".
ECODU 27 Conference Proceedings, 19–23 March, pp. 15–20.

Louis, J.-F. "A parametric model of vertical eddy fluxes in the atmosphere."
Boundary Layer Meteor., 17, 187–202, 1979.

Louis, J.-F., Berkowicz, R. Prahm, L.P. "Global 2-D spectral dispersion model."
1979 Proceedings, WMO Symp. on the long-range transport of pollutants, Sofia, 1–5 October 1979.
WMO – No. 538, pp. 359–366.

Simmons, A.J. "Tropical Stratospheric Waves".
In: *Meteorology over the Tropical Oceans*, published by Royal Met. Soc. 278 pp.

Simmons, A.J., Hoskins, B.J. "The Downstream and Upstream Development of Unstable Baroclinic Waves".
J. Atmos. Sci., 36, pp. 1239–1254.

Stanford, T. NOS/BE 1.3 and INTERCOM 5 experience
ECODU 27 Conference Proceedings, 19–23 March, pp. 40–41.

Stanford, T. Experience with recent NOS/BE and INTERCOM releases, ECODU 28 Conference Proceedings, 23–28 September.

Temperton, C. Burridge, D. "A Fast Poisson-solver for large grids". *J. Comp. Phys.*, *30*, 145–148.

Temperton, C. "Direct methods for the solution of the discrete Poisson equation: Some comparisons". *J. Comp. Phys.*, *31*, 1–20.

Temperton, C. "Fast Fourier Transforms and Poisson-solvers on CRAY-1". In: Supercomputers, Infotech State of the Art Report, Infotech International Ltd., Maidenhead, UK (1979).

Tibaldi, S. "Lee Cyclogenesis and its Numerical Simulation with Special Attention to the Alpine Regions: A Review". *Geophys. Astrophys. Fluid Dynamics*, *13*, 25–49, 1979.

Wiin-Nielsen, A. "Steady states and stability properties of a low-order barotropic system with forcing and dissipation", *Tellus*, *31*, 375–386, 1979.

Wiin-Nielsen, A. "On phase speed errors due to various time differencing schemes", in *Numerical Methods used in Atmospheric Models*, GARP Publication Series, No. 17, Vol. II, 440–466, 1979.

Wiin-Nielsen, A. "On Normal Mode Linear Initialization on the Sphere". *J. Atm. Sci.*, *36*, 2040–2048, 1979.

Wiin-Nielsen, A. "On the Asymptotic Behaviour of a Simple Stochastic-Dynamic System", *Geophys. Astrophys. Fluid Dynamics*, *12*, 295–311, 1979.

Wiin-Nielsen, A. "Atmospheric models". Proceedings from the European Space Agency Workshop CHARM, Ajaccio, Corsica, November, 1979.

Annex 8

ECMWF Publications 1979

Internal Reports

No. 21 Fast Fourier Transforms on CRAY-1

No. 22 Spurious Energy Conversions in an Energy/Enstrophy Conserving Finite Difference Scheme

Technical Reports

No. 10 ECMWF Model – Parameterization of Sub-Grid Scale Processes

No. 11 Normal Mode Initialization for a Multi-Level Grid-Point Model

No. 13 Comparison of Medium Range Forecasts made with two Parameterization Schemes

No. 15 Adiabatic Formulation and Organization of ECMWF's Spectral Model

No. 16 Model Studies of a Developing Boundary Layer over the Ocean

Lecture Notes

No. 1	A.C. Wiin-Nielsen	Normal-mode initialization. A comparative study
No. 2	K. Arpe and L. Bengtsson	Meteorological data: kind, distribution, accuracy and representativeness
No. 3	A. Lorenc	Meteorological data analysis
No. 4	A. Hollingsworth	Introductory dynamic meteorology
No. 5	D. Burridge	Numerical solution of partial differential equations used in numerical forecasting systems
No. 6	A.J. Simmons	Dynamics of large-scale atmospheric motion
No. 7	J.-F. Geleyn	Radiation in numerical weather prediction
No. 8	L. Bengtsson	The energy balance in the atmosphere and its role in the general circulation
No. 9	J.-F. Louis	The parameterization of the planetary boundary layer
No. 10	M. Tiedtke	The general problem of parameterization in numerical models
No. 11	R. Newson, C. Temperton and S. Tibaldi	The ECMWF forecasting system

Workshops

Mountains and Numerical Weather Prediction

Stochastic Dynamic Forecasting

Seminar

Dynamical Meteorology and Numerical Weather Prediction

Other ECMWF Publications

ECMWF Meteorological Bulletins, first in a series describing the Centre's Meteorological Operational System

Report of Workshop on ECMWF future graphical system

Implementation Guide for the Contouring Package

ECMWF Computer Bulletin set
An Introductory Guide to the ECMWF Computer Facility
Contouring Package User's Guide

Annex 9

ECMWF Publications since 1976

Internal Reports (Research Department)

1976

No. 1 User's Guide for the GFDL Model

1977

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 Mod

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 Initialization with Non-Linear Correction for a Multi-Level Spectral Model with Triangular Truncation

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

1978

No. 17 A Comparative Study of Some Low Resolution Explicit and Semi-Implicit Spectral Integrations

No. 18 Verification and Storing with Empirical Orthogonal Functions

No. 19 Documentation of the ECMWF Spectral Model

No. 20 A Study of the Effect of an Interactive Radiation Scheme on a Medium Range Forecast

Technical Reports (Research Department)

1976

No. 1 A Case Study of a Ten Day Prediction

1977

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

1978

No. 9 On Balance Requirements as Initial Conditions

No. 12 Data Assimilation Experiments

No. 14 On Initial Conditions for Non-Hydrostatic Models

Workshops

1977

The Use of Empirical Orthogonal Functions in Meteorology

1978

The Parameterization of Cumulus Convection

Seminars

1975

Scientific Foundation of Medium Range Weather Forecasts

1976

The Treatment of the Boundary Layer in Numerical Weather Prediction

1977

The Parameterization of Physical Processes in the Free Atmosphere

1978

The Interpretation and Use of Large-Scale Numerical Forecast Products

Annex 10

Scale of Contributions by Member States

Belgium	3.68%
Denmark	2.04
Germany, Federal Republic of	24.64
Spain	5.82
France	18.77
Greece	1.26
Ireland	.45
Italy	9.86
Yugoslavia	2.06
Netherlands	4.80
Austria	2.20
Portugal	.87
Switzerland	3.23
Finland	1.50
Sweden	3.93
Turkey	2.15
United Kingdom	12.74
Total:	100.00%