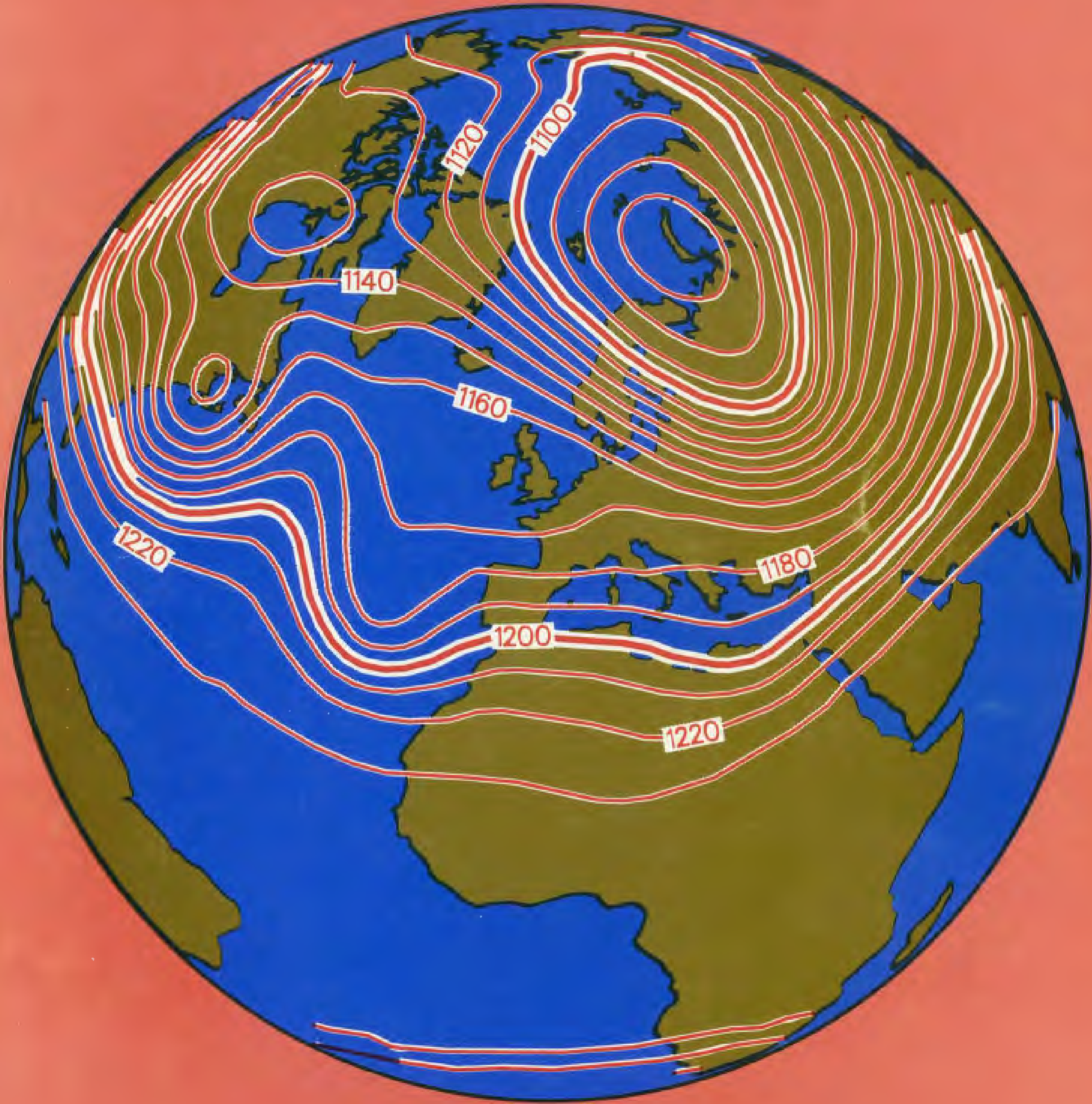
Annual Report 1983



European Centre for Medium Range Weather Forecasts

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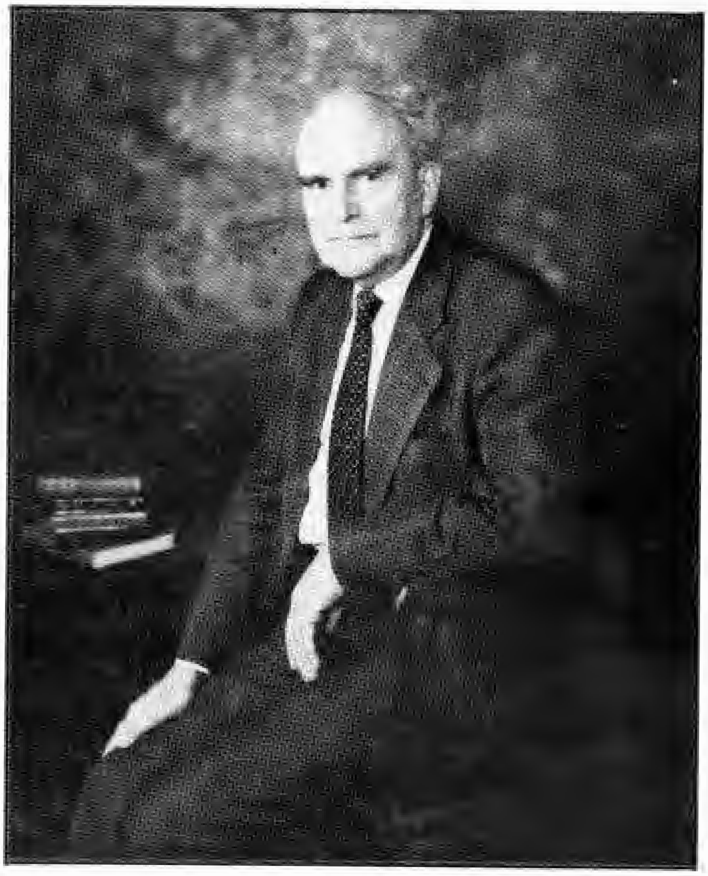


Prof. Dr. E. Lingelbach,
President of the Council

FOREWORD

This is the last foreword which I shall have the pleasure of contributing to the Annual Report of the European Centre for Medium Range Forecasts, as I concluded my term of office in November 1983.

The two major events of 1983 were the first steps into embarking on a new and exciting phase in the Centre's development, that is to say, the acquisition of a second generation computer system and the introduction of the spectral forecasting model as the Centre's operational model.

A great deal of effort was devoted to the accomplishment of these events. Council approved the acquisition of the new computer system at its session held in April 1983, but before that, an intensive process of evaluation had been carried out, and many preparations had to be made leading to installation of the various parts of the system by November 1983. Experimental forecasts were already being run on the new system in early December.

The Member States have by now had time to evaluate the benefits of the spectral model which has been used in operational forecasting since April 1983. The results have been encouraging and we can look forward with anticipation to future developments.

I would like to take this opportunity to wish Professor Mendes Victor, who is now President of the Council, every success in his new office. I would like also to express my thanks and congratulations to all those involved in the work of the Centre; the Director, Dr. Lennart Bengtsson, the staff, and the members of the Council and its Committees, who have all contributed to the achievements of the Centre in 1983. I am very pleased that I shall be able to continue to participate in the work of the Centre as a member of the Council for some time to come.

Dr. E. Lingelbach

Dr. L. Bengtsson, Director of ECMWF

INTRODUCTION

The year 1983 was a very active year for the Centre and a period of considerable achievements. A second generation computer system was procured and installed in an exceptionally short time and a new forecasting model was successfully put into operation. It is gratifying to note from the reports we have received from the Member States, and from other countries who use the forecasts issued on the GTS, that our forecasts continue to improve; it is now generally recognised that they are the best available.

This Annual Report describes the general research, operational and administrative activities during 1983 when the preparation for, and actual installation of the new computer system involved much effort on the part of the Centre staff.

Alongside these activities, many lines of research have been, and are being, pursued, in a continuous effort to improve the model and the forecasts. A number of these research projects are described in detail in this Report. During this year we were able to supplement the computer time available for these projects by means of an agreement for part-time use of another Cray, situated in a nearby establishment.

The groundwork done in 1983 is vital to the future success of the Centre and I am grateful to all those who have devoted themselves to its accomplishment.

Lennart Bengtsson

THE SECOND OPERATIONAL FORECASTING MODEL

Introduction

A new atmospheric model was introduced into operational forecasting at ECMWF on 21 April 1983. The principal differences between this model and the Centre's first operational model are in the adiabatic formulation, which in the new model includes use of spectral components in the horizontal, a more general vertical coordinate, and a modified, more efficient, time-stepping scheme. In addition, new programming techniques and standards were adopted to facilitate both the model's use as a research tool and its adaptation to the CRAY X-MP. A number of revisions were also made in detailed aspects of the formulation of the parameterization schemes. The operational change to this new model was accompanied by a second important change, namely the use of a higher 'envelope' orography.

The new model

The primary factor in changing the operational model was the better performance of the spectral technique following extended inter-comparisons performed once a week over a whole year. In the experiment, the operational grid point model forecasts, with 1.875° resolution, were compared with spectral forecasts made using a model with triangular truncation at total wavenumber 63. The two models used identical parameterization schemes, and required similar amounts of computing resources. Although they often gave very similar forecasts, some clear differences in their overall performance were found. After completion of this experiment, further comparisons were made at regular intervals which confirmed the superiority of the spectral method.

The new model can use any vertical coordinate for which model layers are defined by interfacial pressures of the form

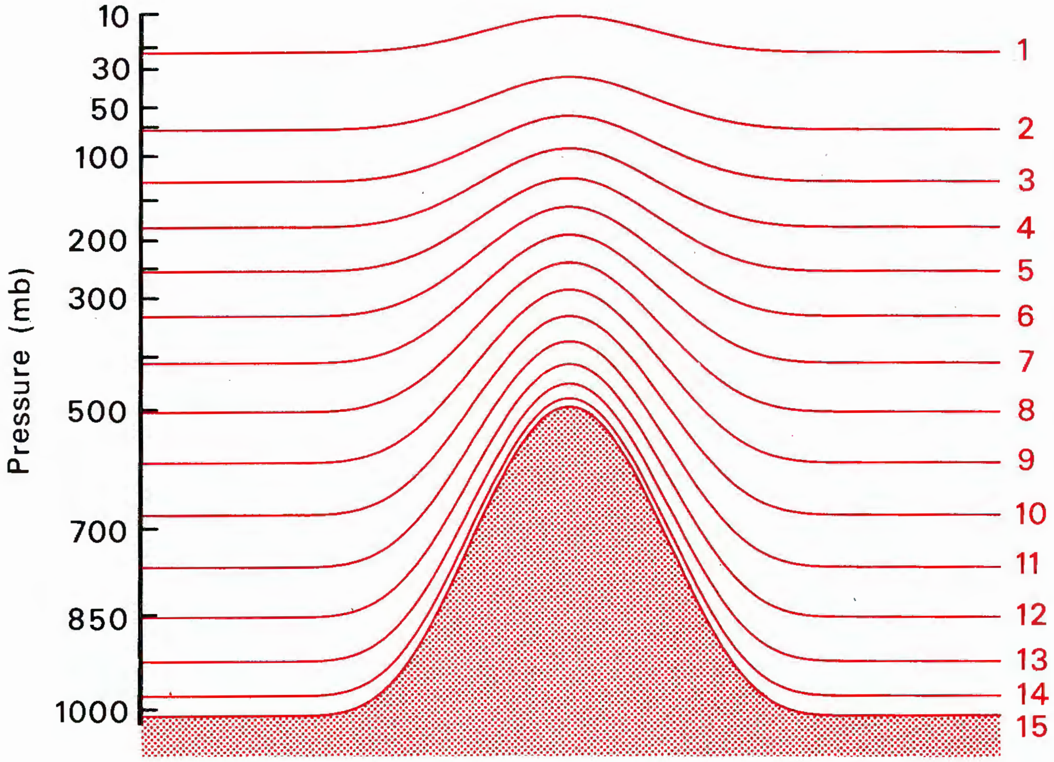
$$p = A + Bp_s$$

where p_s is the surface pressure and the values of A and B depend upon the model layer. When A=0, this reduces to the sigma coordinate used in the first operational model, whereas B=0 gives pressure coordinates. Experimentation has revealed a number of advantages in using a "hybrid" vertical coordinate which resembles the usual sigma coordinate close to the ground, but which reduces to a pressure coordinate at stratospheric levels. Such a coordinate is used operationally with the new model. The 16-layer operational resolution is illustrated in Fig. 1 together with the resolution of the Centre's original operational model.

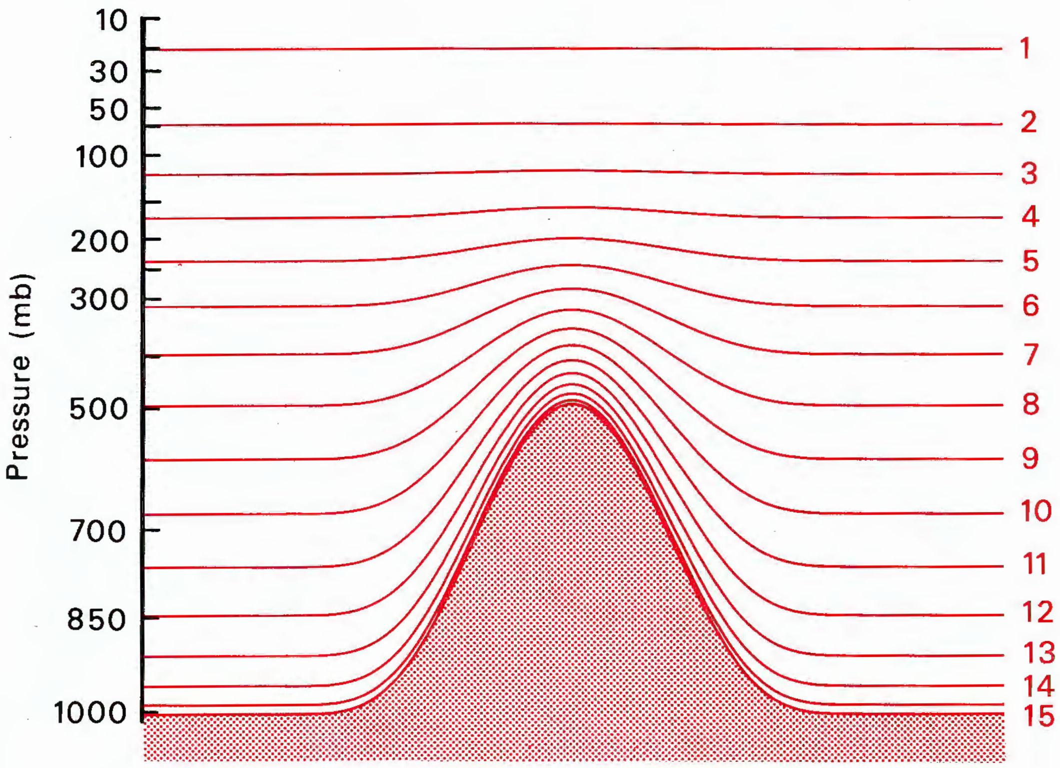
A change has also been made in the time-stepping scheme. A more efficient technique has been developed by using a semi-implicit method to represent not only the usual gravity-wave terms, but also the horizontal advection of vorticity and moisture. The new terms treated implicitly are those describing advection by a reference zonal flow; this allows use of a timestep which has typically been found to be some 30% larger than that possible with the usual semi-implicit scheme. Taken in conjunction with use of the spectral technique and hybrid coordinate, a timestep more than twice as long as found necessary with the operational grid point model has been successfully used (without loss of accuracy) in an extreme case of strong flow in the polar stratosphere of the Southern Hemisphere. A timestep of 20 minutes was adopted for the initial operational use of the new model.

The new orography

Diagnostic and barotropic model studies have suggested that the use of a smoothed grid-square mean orography significantly underestimated the orographic forcing of the synoptic and large-scale wintertime flow in the Centre's grid point model forecasts. These studies led to prediction experiments using an envelope orography formed by adding to the mean orography twice the standard deviation of the actual orography over the grid square, this being computed from a very high resolution (10') data set. Some significant improvements in the accuracy of winter forecasts were found, amounting to a mean increase in medium-range predictive skill of about 6 to 12 hours. The rate of growth of some systematic errors was also substantially reduced.



Sigma levels old operational model



Hybrid levels new operational model

Fig. 1 The vertical resolution of the Centre's old and new operational models.

The above experiments also exhibited a slight deterioration of the short-range forecasts, and diagnostic investigations suggested an overestimation of the forcing from the envelope orography, a suggestion reinforced by limited-area model forecasts of Alpine lee cyclogenesis using higher resolution. Thus, prior to selecting an orography for use with the new model, a further series of experiments was carried out. This led to the operational use of an envelope orography based on adding $\sqrt{2}$ times the standard deviation of the grid-square mean compared to using a factor 2 in the original formulation.

The pre-operational 'parallel run'

After extensive testing of individual components of the new forecasting system, a final pre-operational trial was undertaken. This comprised a quasi-operational run of 19 days immediately prior to the actual operational changeover, with the new model and orography incorporated in the data assimilation. Forecasts were run each day, but 4 of the 19 were terminated before 10 days because of shortages of computing time. This trial was the first full test of the data assimilation for the new model and its use did not appear to bias significantly the comparison between the operational forecasts and the forecasts produced with the new system.

An example from the objective comparison of the two sets of forecasts is presented in Fig. 2. This clearly shows that the new operational model and orography perform better than the old, with an increase in predictability at 1000 mb of about 12 hours in the forecast range from 3½ to 6 days; an even larger improvement is found at 500 mb.

Operational performance

In attempting to assess the overall operational performance of the new forecast model and orography, allowance must be made for the large variation in predictability that can occur from month to month and year to year, and for the other changes to the model and data assimilation that have taken place over the past year. Objective verification of the first six months of operational prediction indicated an improvement over the previous year's forecasts for 1000 mb of much the same order as shown in Fig. 1 for the pre-operational trial. A much smaller improvement was found at 500 mb,

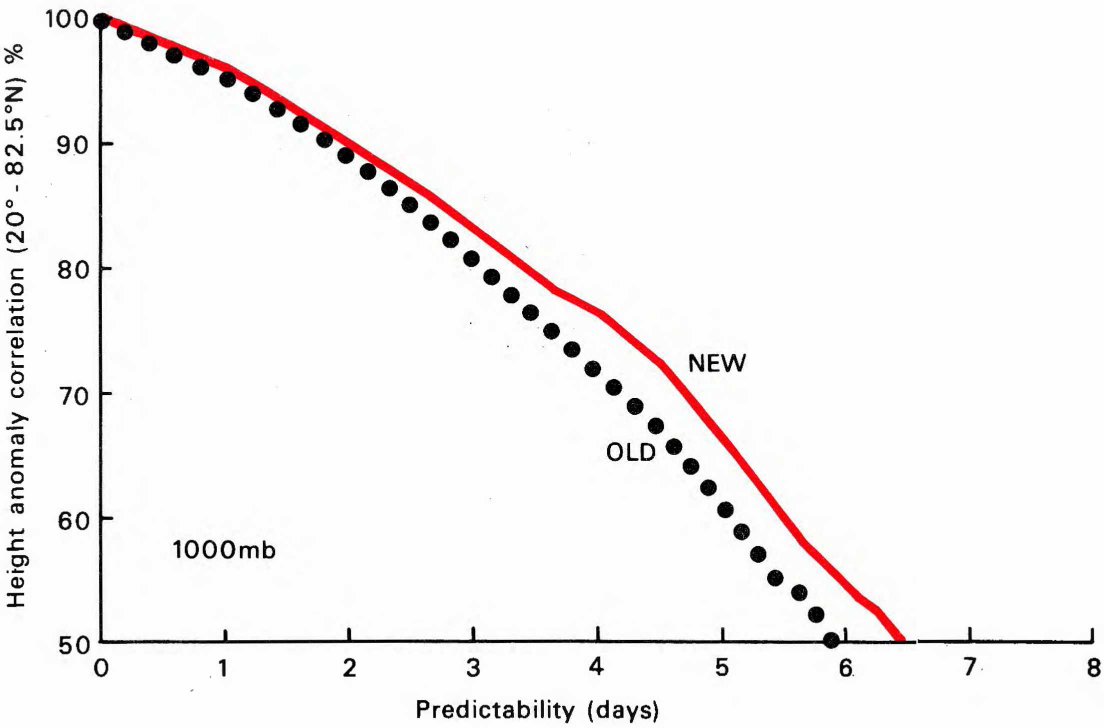


Fig. 2 *Predictability graphs based on anomaly correlations of 1000 mb height for the extra-tropical Northern Hemisphere. Results are based on 15 cases from the "parallel run" between 2 and 20 April 1983. "NEW" and "OLD" denote the new spectral, hybrid-coordinate model, and the former operational grid-point model.*

particularly beyond day 4. This, however, may simply reflect overall variations in predictability from one period to another, although some tests suggested that during the high summer months the envelope orography had little beneficial effect.

Attention has been paid to a number of points of detail in the operational performance of the new system. Minor changes have been made to the radiative parameterization to reduce an excessive cooling over subtropical oceans; to the horizontal diffusion to reduce an excessive precipitation over high ground in summer forecasts; and to the time-stepping scheme to enhance its stability. Some local deficiencies associated with the spectral representation of the envelope orography have also been identified, and a slightly revised orography has been developed for operational implementation early in 1984. Emphasis in model development is now moving towards the preparation of an effective higher resolution version, with improved parameterization schemes, for operational implementation on the CRAY X-MP.

THE SECOND GENERATION ECMWF COMPUTER SYSTEM

Introduction

The European Centre for Medium Range Weather Forecasts has ambitious plans for development of its forecasting system. With the confidence derived from the very real gains in forecasting accuracy during the first years of its operation, gains highlighted in a separate section of this Report, and with a sound basis from the results of its research programme, the Centre plans to achieve improved quality of its medium range forecasts by introducing a higher-resolution model of the global atmosphere. The data assimilation scheme will also be improved to match the resolution of the forecasting model. This major improvement, planned for mid-1985, is entirely dependent on the replacement of the first generation computer system, a replacement begun during the year 1983.

Fig. 3 shows the configuration of the Centre's computer system in December 1983; the changes in the system since December 1982 are highlighted in red.

The main computer

The Cray X-MP supercomputer, which will become the main computer of the second generation system, was delivered to the Centre in November 1983, and was undergoing its acceptance trials at the end of the year. The Cray X-MP is not included in Fig. 3 as it had not been formally accepted by the end of December. With the X-MP, the Centre will be able to achieve at least three times the total throughput of the Cray-1A. Large scale experimentation with higher resolution, alternative vertical discretization and more sophisticated parameterization of sub-grid scale processes is planned for the X-MP. The X-MP, the Centre's first multi-processor mainframe, has two processors, a two-million word memory, a sixteen-million word solid-state storage device (SSD), four additional disks and new disk controllers. The SSD, a large intermediate memory store, appears to the user of the X-MP as a zero latency disk, and will be invaluable in running the sort of programs which large-scale numerical weather prediction calls for.

Signature of the contract for the acquisition of the CRAY X-MP computer

seated, l. to r.: Dr. D. Söderman, Head of Operations Department, ECMWF; Mr. M.G. Dickey, Vice-President, CRAY Research Inc.; Dr. L. Bengtsson, Director, ECMWF; Mr. B. Utting, Account Executive, CRAY Research (U.K.) Ltd.

Standing, l. to r.: Mr. C. Hilberg, Head of Operating Systems Section, ECWMF; Mr. N. Davenport, Managing Director, CRAY Research (U.K.) Ltd.; Mr. G. Hoffmann, Head of Computer Division, ECMWF; Dr. D. Burridge, Head of Research Department, ECMWF; Mr. H. Bosse, Financial Comptroller, ECMWF

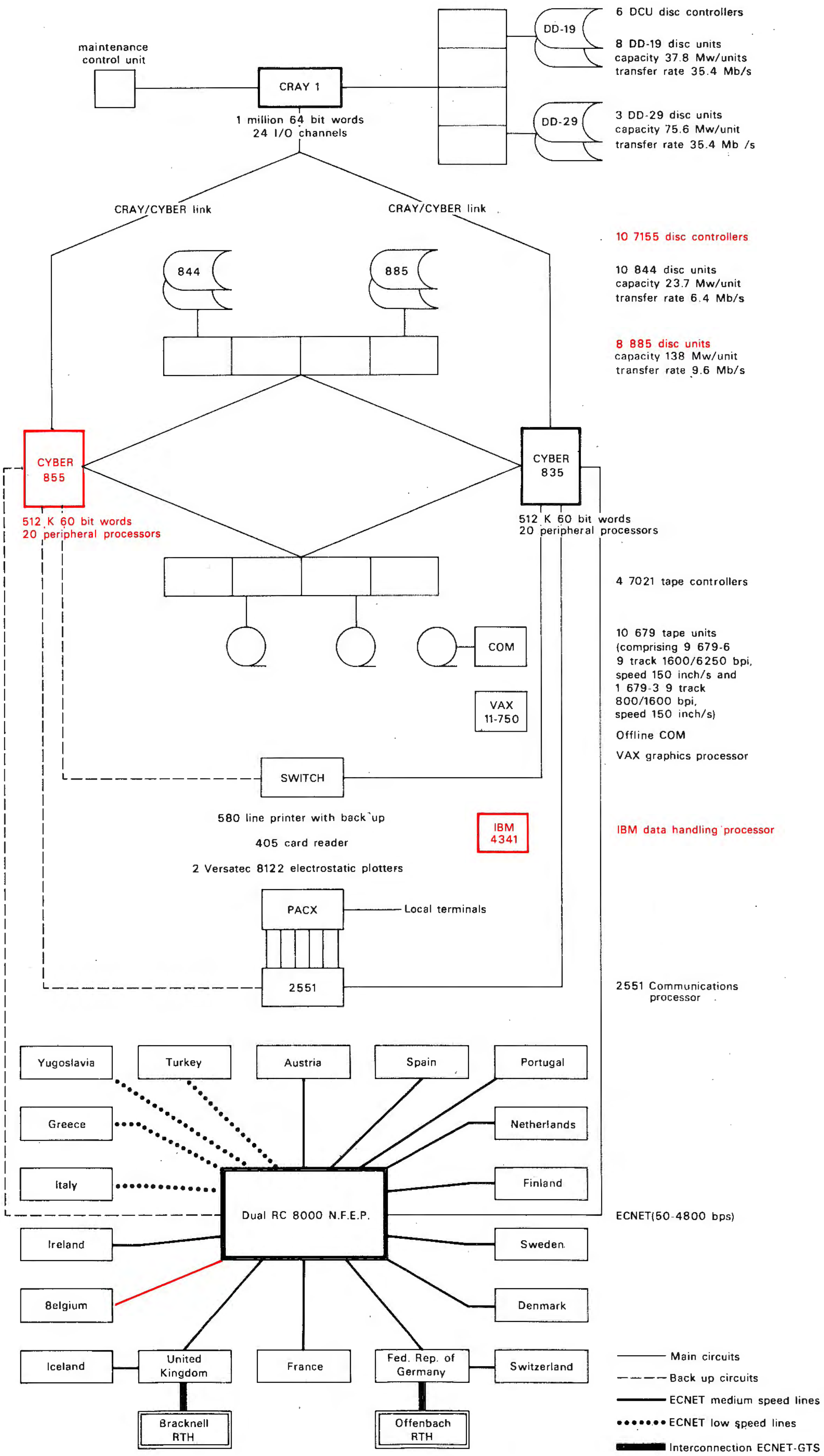


Fig. 3 The configuration, as of December 1983, of the ECMWF computer system and telecommunications network (ECNET) and interconnections to the Bracknell and Offenbach Regional Telecommunication Hubs (RTH) of the global telecommunications system (GTS) of the World Meteorological Organization. Changes made during 1983 are shown in red.

Batch and interactive service, data handling and graphics

The Cyber computers have provided the batch service for development work, the interactive service, and the computer power required for data handling (e.g. preparation of forecast fields from the Cray for dissemination and archiving) and graphics. It was already clear before 1983 that extra power would be required in the future for data handling, especially data storage and retrieval. More sophisticated data assimilation and forecasting systems, with more parameters, more levels in the atmosphere, greater detail in the horizontal coming from the more refined horizontal resolution and more analysis steps to allow for better assimilation of foreseen future (especially satellite) data would clearly require greatly enhanced archival and retrieval systems.

During 1983, then, the batch and interactive services and computing power for processing of meteorological data were improved by replacement of a Cyber 175 by a Cyber 170-855, and an IBM 4341 processor was installed on which the Centre's future archival and retrieval systems will be developed. Furthermore, work has continued on the transfer of the graphics system to a VAX 11/750 computer.

The IBM 4341 processor is the basis of a system to be used for data storage and retrieval. The system will have disks for fast access, a bulk storage device using magnetic cartridges, and finally magnetic tape for the archives. The software will be the Common File System (CFS) developed at the Los Alamos National Laboratories, Los Alamos, USA. Most of the data will be stored on magnetic tape, while data which are frequently accessed will be held on the online disks or on magnetic cartridges.

Data handling at the Centre is characterised by a large demand for meteorological data with rather limited computational requirements, for example, verification of forecasts. The Meteorological Archiving and Retrieval System (MARS) to be implemented with the new computer system will enable the user to define his data requirements in a very logical way. Instead of specifying files, tapes or other storage media, he will request data for a certain date, for a defined area, consisting of specified fields, etc. The data will be accessed automatically, transformed as required, and delivered to the user as a contiguous, local file. All data, both operational and research, will be presented to MARS for storage, and the data will be stored on the IBM system in a uniform format. MARS is a further development along the lines of GETDATA (already in use at the Centre) and will ultimately encompass all the meteorological data of the Centre.

Graphical displays of the results of meteorological work are vitally important. Internal and external graphical workshops have been held to consider the need for a unified graphical system for the Centre. Agreement was reached and decisions made in relation to the graphical facilities to be provided, such as colour raster terminals, colour hardcopy, etc.

It was decided that the basic software for graphics applications would be provided by a proprietary software system while the Centre itself would develop the other parts of the graphical system, for example, contouring, observation plotting, etc.

The design of the new ECMWF system for graphics applications was well under way at the end of 1983. The application language will be very similar to that used for MARS and the VAX 11/750 computer will be used more and more for graphical applications at the Centre.

Computer interconnection

It can be seen from the above that the Centre now has a functionally distributed computer system. In order for it to operate efficiently a high speed data transfer facility between the different parts of the system must be provided. In the spring of 1983, it was decided that a Loosely Coupled Network (LCN) supplied by Control Data Ltd., should be acquired. This will provide file transfer facilities and an interface for programs to communicate with each other. At the end of 1983, delivery was taken of the initial phase of the LCN, a high-speed coaxial trunk that will ultimately connect all major components of the Centre's computer system.

VERIFICATION OF OPERATIONAL FORECASTS

Introduction

The basic output product of ECMWF is its operational weather forecasts up to ten days. The work of any organisation is judged by the quality of its results; the work of ECMWF can be assessed on the usefulness and quality of its numerical forecast products. The usefulness of the forecasts to the Member States can be judged from the very wide, and growing, range of applications and users of medium-range forecasts within the Member States; this is considered in a separate section of this Annual Report. The quality of the forecasts can be assessed in different ways, subjectively and objectively. They are assessed in the Centre itself, in the Member States, in non-Member States and under the auspices of the World Meteorological Organisation through the work of its Commission for Atmospheric Sciences. In this section of the Report, recent verification of the operational forecasts of the Centre is reviewed.

Improvements in forecast quality to 1983

Fig. 4 shows the performance of the ECMWF Northern Hemisphere forecasts from September 1979 to the end of 1983. The score is derived from monthly means of daily averages of the anomaly correlations and standard deviation of the errors of geopotential height and temperature forecasts for levels between 1000 and 200mb (height) and 850 and 200mb (temperature). The monthly mean values show large seasonal variability in the skill of forecasts. The twelve month running mean or moving average of the scores shows the long term trend of the skill. Note that the number of days of predictive skill, as measured by the twelve month running mean, remained almost constant at close to six days for much of 1982. The improvement during 1983 is consistent with tests carried out before the introduction of the new operational spectral model, with an improved (envelope) representation of orography. The improvements in the forecasts overall may also be associated with a series of refinements in the Centre's data assimilation system which have been implemented in the light of operational experience. These include "blacklisting" of ships and other data, including radio-sonde data, in cases where ships or stations systematically sent incorrect data.

Incorporation of physical forcing in the initialisation has particularly affected the forecasts in low latitude.

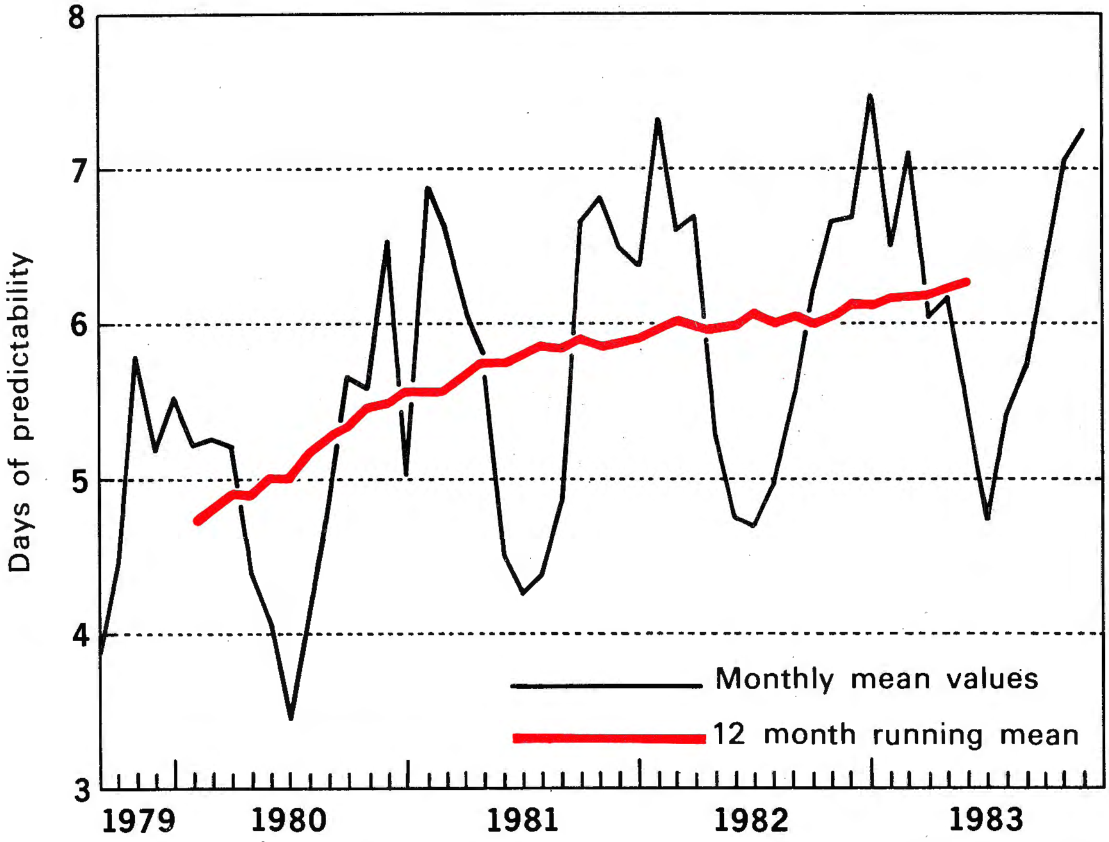


Fig. 4 *A measure of the skill of ECMWF Northern Hemisphere forecasts for the period September 1979 to December 1983. The number of days of predictability is derived from monthly means of daily averages of the anomaly correlations and standard deviation of the errors of geopotential height and temperature forecasts for levels 1000 to 200 mb (height) and 850 to 200 mb (temperature).*

Verification of ECMWF forecasts in the Member States

Several of the Member States have sent summaries of their verification of ECMWF forecasts, both subjective and objective, to the Centre during 1983.

The conclusions reached include the following:

- Cyclone tracks over the eastern Atlantic and Europe are often predicted to be too far to the south, in particular beyond three to four days. Some improvement has been found for the latest winter of 1982/83 (Denmark).
- Some very good ECMWF products during the winter allowed the prediction of adverse weather conditions and the issuing of warnings to the public five days ahead (Greece).
- Skill scores for almost all weather elements are positive up to H+144 (Netherlands).
- Percentage of correct D+6 forecasts varies from 64% in winter to 59% in summer (Switzerland).
- On average, the range of useful forecasts as assessed subjectively has increased from 5.1 days in 1981 to 6.0 days in 1983 (Sweden, see Fig. 5).

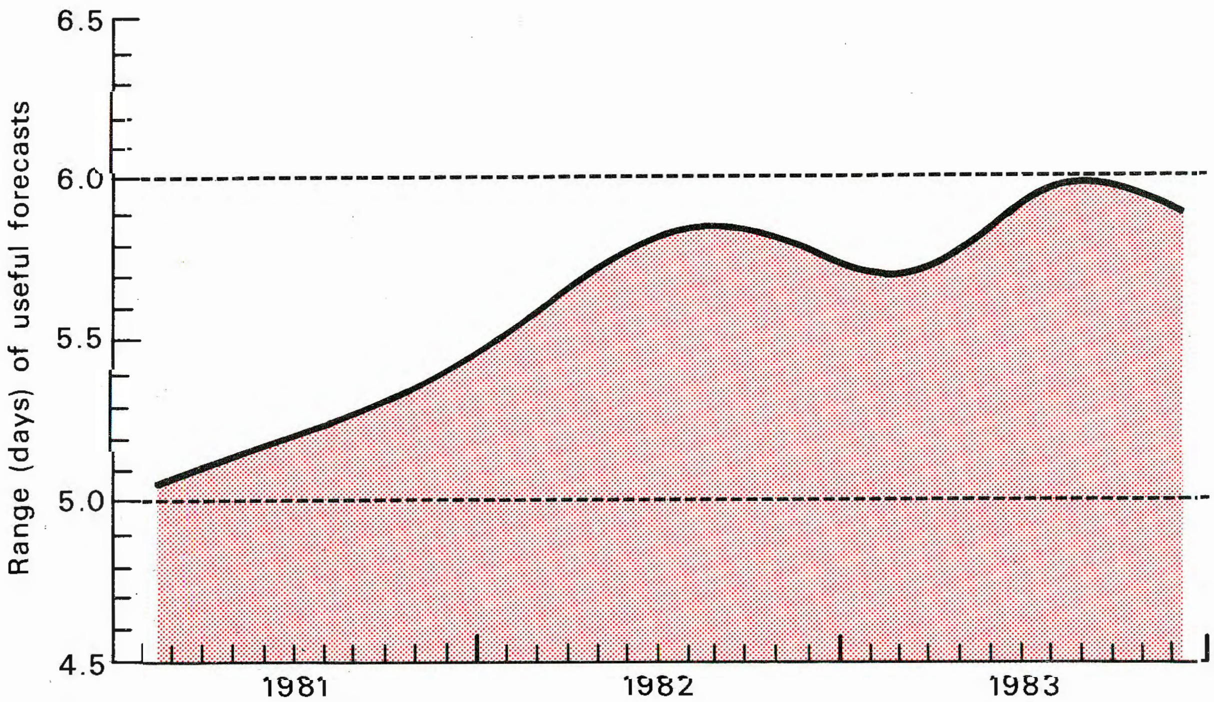


Fig. 5 Average range of useful ECMWF forecasts as assessed at SMHI, Sweden, to December 1983.

Tropical forecasts

The tropical forecasts have not been evaluated in as extensive or objective a way as those for the extratropical Northern Hemisphere but there is no doubt that, at present, their accuracy and usefulness is substantially less. Objective verification indicates a limited short-range predictive skill in the middle and upper troposphere. Thus for the tropical zone from 18°N to 18°S the root mean square error (RMSE) of the 2-day forecast vector wind averaged for 1983 is 4.8 ms^{-1} at 500mb compared with 6.8 ms^{-1} for persistence. Seasonal variability has been examined for limited regions. For the Northern Hemispheric area 72°E - 102°E, 6°N - 33°N (which includes India) the RMSE of the summer (June, July and August) 2-day forecast was 7.7 ms^{-1} at 200mb compared to 9.0 ms^{-1} for persistence; the winter (December, January and February) forecasts were appreciably better than persistence with corresponding RMSEs of 9.4 ms^{-1} and 14.0 ms^{-1}.

The indication from both subjective and objective assessments of the tropical forecasts is that there are serious deficiencies in the parameterization of convection, and a substantial effort to understand and correct these deficiencies is currently being made.

OPERATIONS DEPARTMENT

Introduction

The year 1983 has been a year of intense activity for the Operations Department. Preparation for the Centre's second generation computer system involved much effort and planning; the Cray X-MP second generation system was delivered and installed late in the year. Other computer equipment, including a Cyber 170-855 and an IBM 4341, was delivered and installed. Also, at the end of the year, the initial phase of the Loosely Coupled Network (LCN), which will form a high-speed data transfer network, was received in the Centre.

During 1983, the computer resources available for the Centre's research work were supplemented by time rented on a Cray-1S installed at the Atomic Energy Research Establishment, Harwell, approximately 50km from the Centre. A total of 285 research forecasts to ten days were carried out on this computer; this in spite of inevitable difficulties involved in using the system from a distance, and with operators who were unfamiliar with the Centre's requirements. With considerable effort on the part of Centre staff, a smooth-running and efficient system for using the Harwell computer was organised.

Verification of operational forecasts continued. Objective scores of the Centre's numerical forecast products showed that, by the end of 1983, the average useful skill of the forecasts had increased to over 6 days, compared with less than 5 days when the Centre started its operational activity. Verification of forecasts in the Member States provided the Centre with much useful information during the year.

Operational use of the Centre's forecasts, not only in the Member States, but also in many other countries around the world, has continued to intensify. Reports on many of the uses of ECMWF forecasts have been received, emphasising the growing dependence on the Centre's products for medium-range weather prediction.

The Centre also provided a special forecasting service to the Spacelab photogrammetry experiments in December 1983, providing forecasts of cloud along the sub-satellite track of the Space Shuttle.

Use of ECMWF forecasts in the Member States

During the year, reports were received from all Member States on the use of ECMWF products in their national meteorological services.

Of the 17 Member States, twelve reported that they either already use or plan to use ECMWF products in statistical forecasting schemes, four using the model output statistics (MOS) technique, three the perfect prognosis method (PPM), and one using both methods in different forecasting schemes; the others do not specify which method is used. Nine Member States reported that they use or plan to use ECMWF products as first guess fields or boundary values in their own limited area modelling. Nine Member States report on the use of experimental products.

Lists of the users of medium-range forecast products were provided by several Member States. The areas of use include agriculture, the energy sector, engineering and construction, air pollution, tourism, ship routing, offshore platform forecasts, and the general public. Several Member States reported separately on the economic benefits of ECMWF products to their national economies. Where quantitative estimates were possible, the benefits of weather services were shown to exceed the costs several times over.

There is much useful information in the verification results contained in the reports. The extensive range of future plans, including forecasting to D+10, use of 5-day mean fields, limited area modelling, more statistical interpretation and greater use of the Centre's archives, indicate the high level of satisfaction and confidence felt by the Member States in the Centre.

Use of ECMWF forecasts in non-Member States

During 1983 the Centre continued to distribute a selection of its products on the Global Telecommunication System of the World Meteorological Organisation. These included mean sea level pressure and 500mb height fields from analysis to five day forecasts at daily intervals for the Northern Hemisphere and to four day forecasts at daily intervals for the Southern Hemisphere. For the tropical area 35°N to 35°S, the wind fields at 850mb and 200mb were distributed; all fields were on a 5° x 5° latitude-longitude grid. Observational data received via the Global Telecommunication System from all over the globe is crucial for the Centre in producing and improving its forecast products.

Valuable feedback was received by the Centre on the quality and usefulness of Centre forecast products for the regions of the globe of interest to many non-Member States. Regular use is now made of the Centre's forecasts for the Southern Hemisphere in Australia, New Zealand and in South Africa. Northern Hemisphere or tropical forecasts are used by the People's Republic of China, Japan, the United States, Hong Kong and India. In Australia and China, the Centre's products are decoded at the National Meteorological Centre and the decoded charts are subsequently disseminated to regional offices for use daily in operational weather prediction.

Reports are also received on the quality of the Centre forecasts. These include objective scores; the Royal Observatory, Hong Kong, for example, verified ECMWF 500mb height forecasts each month against radiosonde data and against analysed fields, and the National Meteorological Centre, Washington, has carried out an extensive intercomparison of ECMWF and NMC forecasts. The greater skill of the ECMWF products is clear in all the reports. Fig. 6 shows the scores of ECMWF forecasts, computed by the New Zealand Meteorological Service, compared with the scores of locally-produced forecasts. Note that the Centre's 96 and 48 hour forecasts for the New Zealand area are more skilful than the New Zealand 48 and 24 hour forecasts respectively; the Centre's 72 hour forecasts have similar skill to those of the 24 hour manually produced forecasts of 1977.

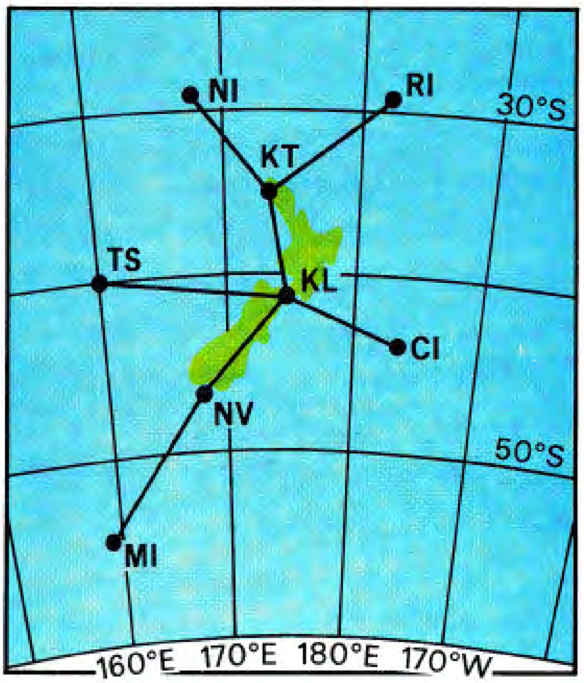


Fig. 6 (a) *Grid of right points used for verification of MSL prognoses over New Zealand. A skill score is computed using the pressure differences between the points joined by bold lines.*

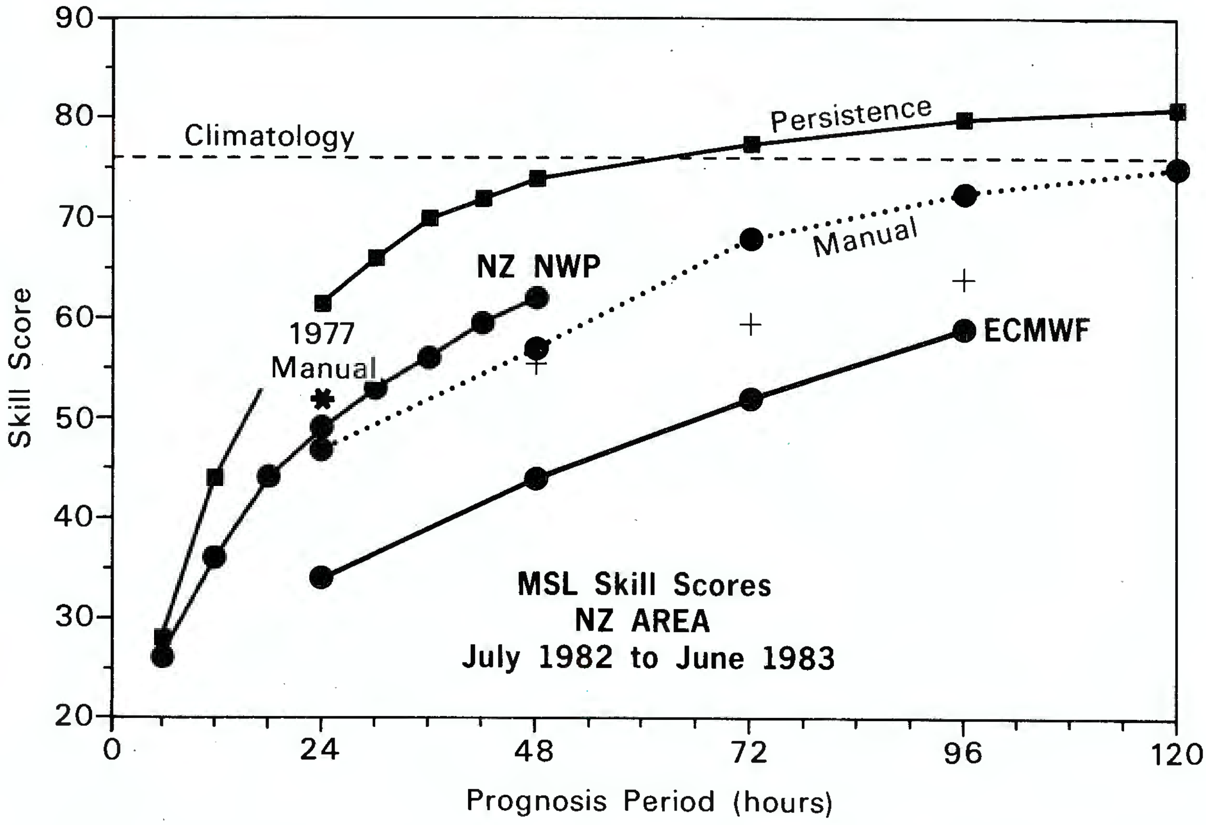


Fig. 6 (b) *MSL S1 skill scores computed over the area given in Fig. 6 (a) Scores are for the period from July 1982 to June 1983 inclusive, except for the asterisk giving the average score for 24 h prognoses in pre-NWP days of June to September 1977, and the 48, 72, 96 and 120 h scores for manual forecasts which are for April to August 1983. The plus signs beneath the latter manual scores denote scores corrected for the difference in forecasting difficulty.*

ECMWF forecasts in the Spacelab experiment

Following the adoption by Council of guidelines governing the dissemination of ECMWF operational products, cloud forecasts from the ECMWF model were used as guidance for the metric camera experiment on board the Space Shuttle in the period 2-5 December 1983. The camera had only limited film; the cloud forecasts were used in order to assist with the identification of cloud-free areas for its operation.

For this guidance to be issued, a study was made to assess ECMWF cloud forecasts, by comparison with observational data (conventional surface-based and Meteosat cloud pictures) in the period preceding the actual shuttle flight, and along the sub-orbital tracks to be followed by the shuttle during the period of the experiment.

During the time of the actual shuttle flight, cloud forecasts from the ECMWF model were sent to Mission Control at Houston. Forecasts of total cloud cover at specific points and times along the operational flight paths of Spacelab were required. Numerical output for each point was produced and transmitted to Houston between 2300 and 0200 GMT during the period 27 November-5 December 1983. The forecasts were linearly interpolated between consecutive time steps centred on the mean time of the flight, the first operation starting at 0333 GMT on 2 December over the Himalayas and the last at 1320 GMT on 5 December over Central America. A simple statistical correction, derived from the earlier study, was applied to the model output data.

The European Space Agency reported that the cloud forecasts from ECMWF were extremely useful, to the point of being the major criterion determining the choice between available target areas and programming the metric camera imaging sequences. It is believed that this is the first time that such detailed cloud cover forecasts have been available and used in a space programme to optimise the data quality of an earth-observing optical instrument. Indeed, with the high costs of obtaining and processing satellite optical data, ESA sees that this first experiment may point the way to improved programming efficiency of similar future space missions to enhance the quality of retrieved images and to minimise operational costs.

Computer installation at ECMWF in 1983

The year 1983 saw the start of implementation of the plans for new computer systems. Preparatory work, consisting of installation, planning and site preparations, was quite extensive. Taking account of the fact that the Centre is operational 24 hours each day, year round, the scheduling of large scale installation work, which affects the Computer Hall environment and site services such as chilled water and electricity, is very critical. Precautions had to be taken to avoid disruption of the computer service. Consequently, the installation work could not be carried out continuously, and the contractors' work had to be planned accordingly. The layout of the Computer Hall as at December 1983 is shown in Fig. 7.

The computer installation work for 1983 is summarised below:

VAX

Being a small system with two disk drives, this required only the installation of a new 50HZ electrical distribution panel and cabling. Communication circuits were installed to connect the VAX to the Centre's in-house terminal network.

CYBERS

Initially there were two Cybers at the Centre, the Cyber 175 and the Cyber 835. A new Cyber 855 was to replace the Cyber 175, but due to the nature of the new 855 product and the importance of the 175 in the Centre's work, risks had to be minimised; also installation costs had to be kept to a minimum.

Consequently, the 855 replaced the 835 until the 855 passed final acceptance tests, then the 175 was disconnected and the 835 was reconnected. This process also saved the cost of a temporary installation and meant that there were no redundant services after the 175 was disconnected. The final changeover of Cybers was achieved during a week-end and forecasts were produced notwithstanding, according to the normal schedule.

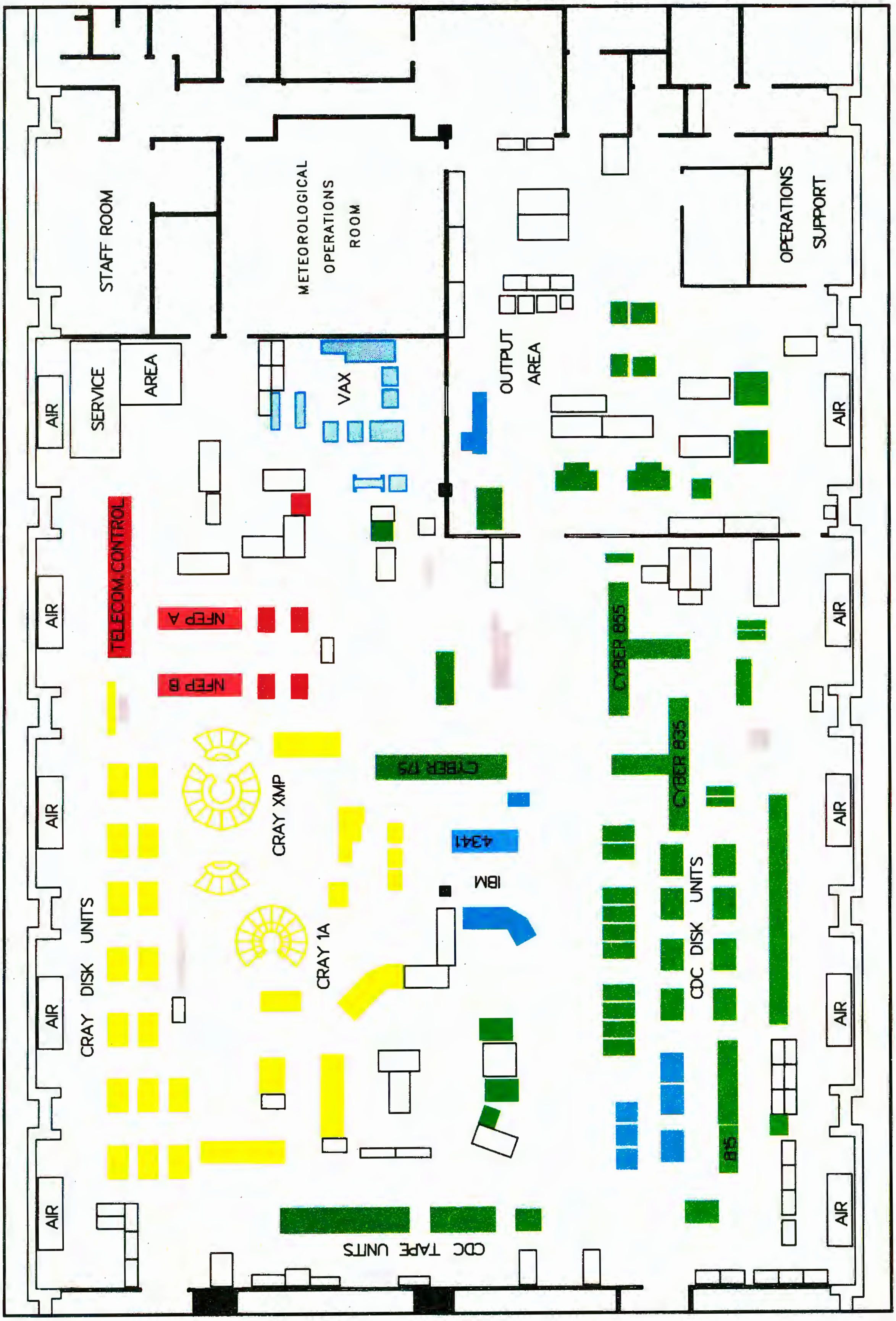


Fig. 7 Plan of ECMWF computer Hall, December 1983.

A new chilled water circuit was installed for the Cyber 800 series machines and a new electrical distribution panel also had to be provided for them. For the local area network, a coaxial cable 'trunk', with taps for access by the network adaptors, was installed under the Computer Hall floor.

Preparation for a Cyber 815 (the LCN gateway to the Cray computer) consisted mainly of provision of electrical services which were incorporated with those needed for the other Cybers. Two additional 885 disk drives and controllers were installed; again these items only required electrical services.

IBM

Planning for the IBM installation was more complex due to the phased installation dates over a period of more than one year and the effect on floor space where conflicts occurred with the schedules for equipment to be shipped out, such as the Cray-1A and the Cyber 175.

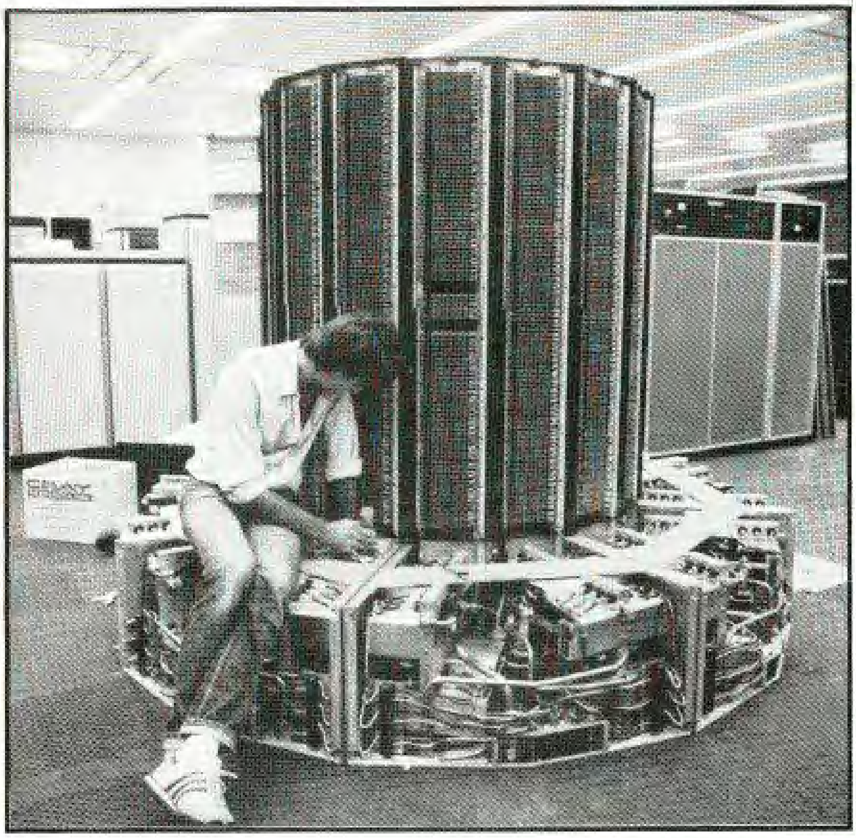
To avoid a fragmented layout, an agreement was reached with IBM to re-install the equipment as necessary at each phase of upgrading, leading towards the final desired layout.

The initial preparation work necessitated the installation of a new electrical feeder cable from the plant room to the Computer Hall where a new distribution panel was installed.

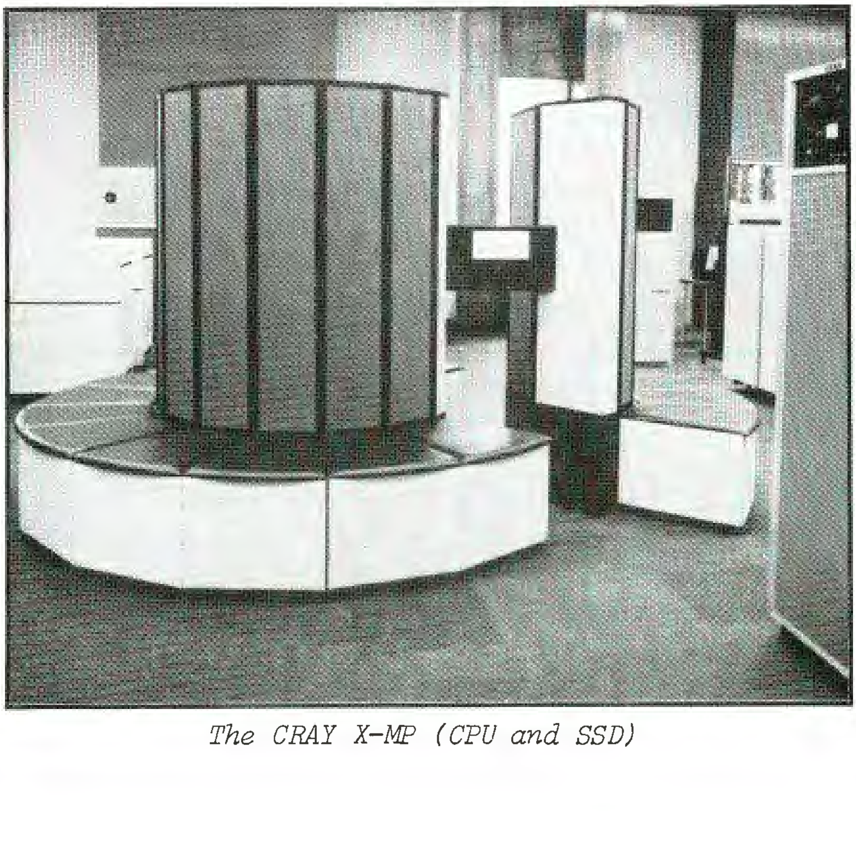
For the IBM 4341 system, a number of coaxial terminal circuits also had to be installed to connect the offices concerned.

CRAY X-MP

Despite previous experience of installing two other Cray computers, planning for the X-MP was quite complicated, mainly because this machines had to run in parallel with the existing Cray-1A.



The CRAY X-MP in course of installation at ECMWF



The CRAY X-MP (CPU and SSD)

All services had to be duplicated for a short while but unnecessary duplication in the long term was avoided. On the electrical side, the Cray-1A supply was rewired temporarily to be fed from a spare circuit in the chilled water plant room, thus avoiding the cost of installing an additional supply line in the electrical plant room. A new circuit for the X-MP was then fed from the original Cray-1A supply.

Electrical plant room work was extensive for the X-MP. Three 150 Kw, 400Hz frequency converters, each weighing 6500 kg were installed, and elaborate ductwork was constructed to provide cooling for these machines. Two refrigeration condensing units, each with a cooling capacity of 170 Kw, were installed. The main chilled water circulation pumps had to be replaced with larger ones and new chilled water supply pipes were installed, to supply the two new condensing units and the existing one for the Cray-1A.

In order to bring the refrigeration pipes from the new condensing units in the plant room to the Computer Hall above, it was necessary to drill two 14cm diameter holes through about 36cm of the reinforced concrete floor, without creating dust in the Computer Hall or disrupting normal computer operations.

This work took about 6 hours and was carried out using a diamond tipped core-drill. Cooling and dust control was achieved by pumping water around the drill and sucking it away with a vacuum cleaner.

Preparation of the Computer Hall floor for the X-MP configuration (which has a total weight of 11,700 kg) involved the cutting of 41 small holes, of varying shapes, and conforming to an accurate geometric pattern in alignment with the unique mainframe shape. These holes give access for power and logic cables and also provide access for 23 refrigeration hoses. In order to spread the weight of the mainframe, plus the IOS and SSD (totalling 8129 kg with a point loading of 3515 kg/m^2) 46 additional floor jacks were installed under the false floor.

Use of the CRAY-1S at Harwell

From 1 July 1982 to 30 November 1983, the computer resources available at the Centre were supplemented by time rented on a Cray-1S installed at the Atomic Energy Research Establishment, Harwell, approximately 50 kilometres from the Centre. These extra resources were invaluable in extending the Centre's research capabilities; however, considerable effort was required to organise a smooth-running and efficient system.

During 1983, all forecast experiments run by the Research Department represented the equivalent of 675 10-day forecasts with a global N48 gridpoint or T63 spectral forecast model. Of this workload, 285 integrations were carried out on the Cray-1S at Harwell. Thus, 42% of the Research Department forecast activities were accomplished with rented computer time.

Full use was made of the Harwell resources in spite of the difficulties caused by use of a remote system and reliance on operators unfamiliar with the Centre's requirements. A 10-day forecast requires 3-6 Mwords of input data (one magnetic tape) and produces 35-45 Mwords of results (three magnetic tapes). Three separate post-processing jobs are required to be run on each twenty sets of output data. Since the Centre's use of the Cray-1S was not supported by the provision of front-end facilities, such as disk space, and with operators lacking knowledge of the Centre's experimentation, it was necessary to automate the process with a controlling supervisory program. Further complications were caused by having to submit all jobs through the Harwell IBM front-end system and by various differences in the operating systems. Some problems with hardware on both the Cray-1S and IBM also caused some delays. Station software problems were responsible, on occasion, for the loss of jobs, as were occasional operator errors, especially in the early days.

In spite of all these problems, time rented on the Cray-1S at Harwell was exhausted on 30 November 1983, one month ahead of the schedule.

Table 1 gives more detailed information on the resources used at Harwell.

	CP hours	Elapsed hours	K units
1 January - 30 June 1983	429	783	558
1 July - 30 November 1983	432	742	564

Table 1 Use of the Cray-1S at Harwell, in Central Processor hours, elapsed hours and 1000s of ECMWF accounting units.

RESEARCH DEPARTMENT

Introduction

1983 was both an active and transitional year for the Research Department. In April the Centre's first operational model (a global grid point model) was replaced by a spectral model employing spherical harmonics for the horizontal representation. In addition a number of other improvements were implemented. Traditional scores indicate an improvement over the grid point model which is by and large in agreement with previous evaluations. Further details of the new model have already been given in a previous chapter of this Report.

The Centre's data assimilation scheme has been working operationally now for more than four years. Taken together with experience gained from assimilating the observations for the First GARP Global Experiment (FGGE) year this has provided ample opportunity to monitor the practical performance of the assimilation technique. This practical experience supported by theoretical studies has supplied the basis for the development of a comprehensive set of modifications. Some of these were benchmarked in the latter part of 1983 and will be incorporated into operations in 1984.

The Centre's medium-range forecasts are very sensitive to the quality of the analysis; the importance of analyses for short and medium range forecasts has been the subject of a fruitful collaborative project involving the Centre, the UK Meteorological Office and the National Meteorological Centre, Washington. An important result arising from this work is that analysis errors have most impact when they occur in baroclinically unstable regions. An example of this kind of behaviour is described later; also a more detailed account of the work done on data assimilation is given.

The main effort in numerical modelling during 1983 was directed towards the preparation of the new forecasting system planned for 1985. The first phase of this work culminated in the introduction of the spectral model in April; the second phase now in progress entails adapting the model to the CRAY X-MP and the development of higher resolution versions. Research on, and development of, parameterization schemes involved

- the continuing development of boundary layer parameterization schemes in which vertical turbulent exchanges depend on the forecast level of turbulent kinetic energy;

- the evaluation of a variety of parameterizations for penetrative and shallow convection;

- the evaluation of the sensitivity of the tropical heat sources and of the mean flow to cloud-radiation feedback.

An example of the experiments carried out with a limited area model to study the importance of horizontal resolution is given later.

The diagnostic studies carried out in the Research Department are an important means of understanding the origins of systematic errors in the Centre's forecasts. The large-scale errors in higher-latitude jet stream structures are suggestive of an erroneous forcing by transient eddies, and the structures of these eddies could in turn be sensitive to errors in static stability and in sub-tropical jet streams. A considerable amount of work has been carried out on the diagnosis of the errors in the transient waves in the Centre's forecasts and some of the results are summarized in a later section.

Observing system experiments (OSE) are a very important part of the Research Department's work programme. It is recognised internationally that the Centre's work in this area will contribute valuable input to the planning of a viable global observing system on which the accuracy of medium range weather forecasting depends. During 1983 the Centre joined an international collaborative project to carry out observing system simulation experiments (OSSE). These experiments will help both to evaluate future global observing systems and to compare the different assimilation techniques in use in operational and research centres.

In this Introduction, a brief outline has been given of the extensive range of research and development carried out in the Research Department. The rest of this section concentrates on the following four topics:

- data assimilation studies;
- impact of analysis differences on medium range forecasts;
- high resolution experimentation;
- errors in the model's baroclinic waves.

Data Assimilation studies

The data assimilation scheme has a 6 hourly cycle which consists of three stages: an analysis, an initialization and a 6 hour forecast. As a means of assessing the relative importance of each of these, the changes brought about by three processes were examined; as an example Fig. 8 shows the root mean square changes at 500 mb for October 1983 (based on 12GMT assimilations).

In the extratropical Northern Hemisphere most of the evolution is achieved by the 6 hour forecast. The observational data introduced at the analysis stage produce a relatively modest adjustment, whilst the normal mode initialization causes a smaller (though crucial) modification. Examination of the geographical distribution of the errors revealed that there are localised maxima along the oceanic mid-latitude storm tracks. These are associated with the rapid synoptic changes in this region and the inadequate observing network.

The situation in the Southern Hemisphere is less satisfactory. As in the Northern Hemisphere, the biggest changes in both the forecast and analysis are in the depression belt, the analysis changes being affected by the availability of data. Overall the analysis changes are fractionally greater than those of the forecast.

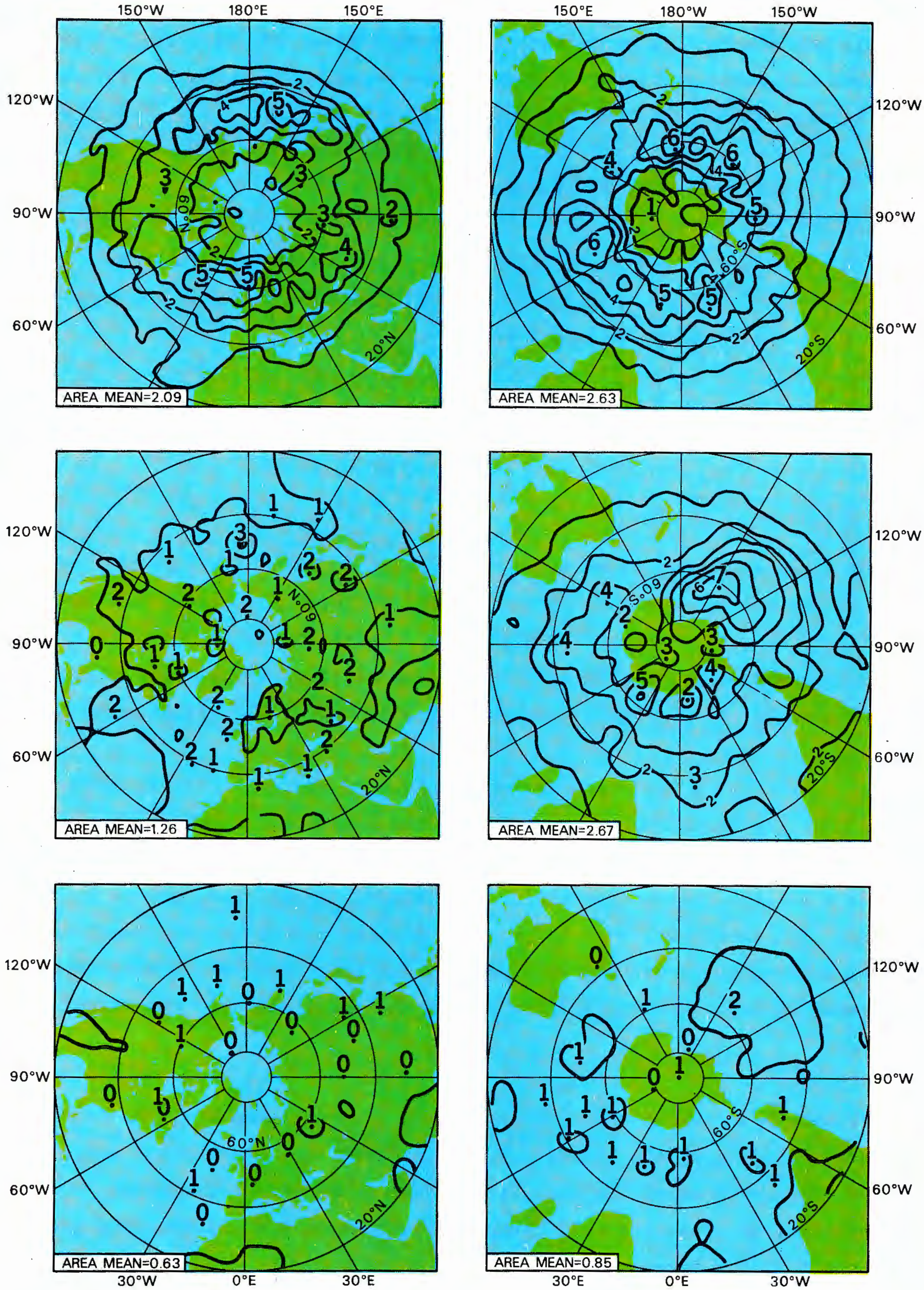


Fig. 8 Root mean square values of the geopotential increments at 500 mb for October 1983 for the forecast, analysis and initialisation stages of the data assimilation scheme. (left-NH; right-SH) Contour interval= 1 dam.

A comprehensive system of control programs was introduced into the operational suite to monitor the data assimilation. It proved valuable in highlighting problems with the assimilation and suggesting ways in which it could be improved. This led to changes in the data assimilation which are being evaluated for operational implementation.

Over the year it was noticed that the assimilation scheme does not adequately resolve the intensity of the observed weather systems. To investigate this it was necessary to examine carefully the underlying constraints imposed by the optimum interpolation scheme on the final analysis. The approach taken was to carry out experiments with idealised configurations of observations on differing scales and with differing relationships between the height and wind increments. An example of the results is given in Fig. 9 which shows the response amplitudes of the height and wind, as a function of observation spacing and wavelength of the imposed disturbance, for various data configurations. Particular features of note are the general inability of the present scheme to resolve small disturbances (see the sensitivity to scale in Fig. 9a); the inability to resolve divergent flows (contrast the responses in Fig. 9b and 9c); and the reinforcing impact of geostrophically consistent height and wind data (Fig. 9d shows the best response of all). Results such as these have yielded a better understanding of the characteristics of the Centre's optimum interpolation scheme.

Impact of analysis differences on medium range forecasts

Experiments were performed as part of a collaborative study between ECMWF, the UK Meteorological Office and the NMC, Washington to examine the response of three advanced analysis-forecasting systems to identical inputs of observational data (FGGE IIb data). In some cases there were large local differences in the analysis; the subsequent forecasts led to an amplification of the differences and this assisted in deciding which was the best analysis. It was usually possible to identify the reasons for the differences in the analyses and this in turn often indicated means by which the analysis schemes can be improved. The divergence between the forecasts provides some insight into the limit of predictive skill due to uncertainties in the analyses.

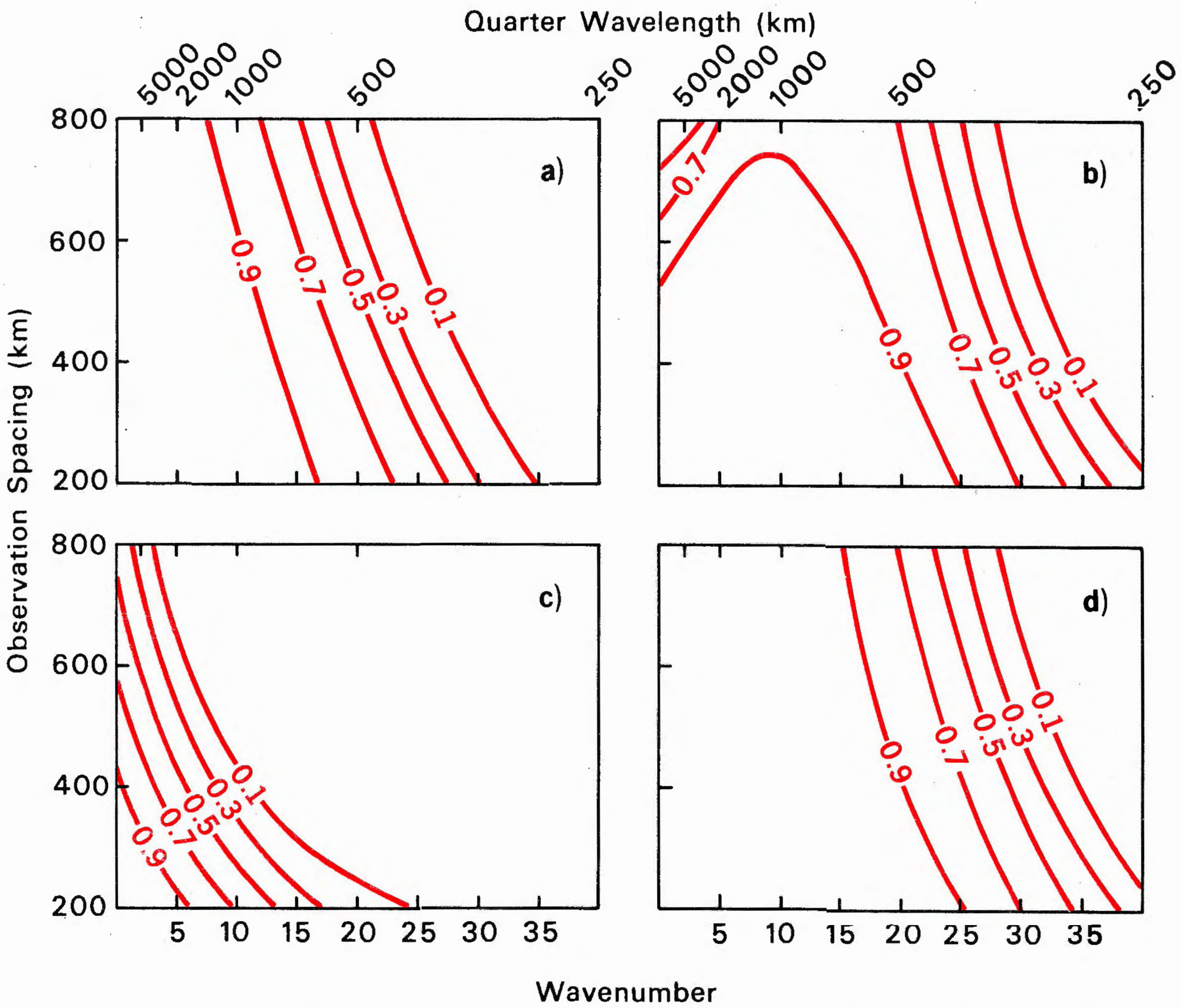


Fig. 9 *Response diagrams as a function of input wavenumber (abscissa) and observation spacing (ordinate). On the top of each diagram is also shown the quarter wavelength (km). (a) geopotential response to geopotential observations, (b) wind response to non-divergent wind observations, (c) wind response to irrotational wind observations, (d) the response of wind to geostrophically consistent winds and heights.*

The usefulness of this approach can be illustrated by considering a case where uncertainties in the initial analyses over the Pacific had an impact on the medium range forecast for Europe. At 00GMT 18 February 1979 the observation data over the northern Pacific included a large amount of satellite data (mainly temperature soundings, but also some cloud drift wind data), a reasonable coverage of ships, some data from aircraft and Ocean Weather Ship P (50°N, 145°W). Differences between the ECMWF and NMC analyses arose from a conflict between thickness data from the satellite soundings and OWS P; the two data assimilation schemes treated the conflicting data in different ways.

The differences between the analyses are illustrated in Fig. 10a which shows the differences in the 300 mb height field (differences outside the north Pacific have been excluded). By day 2 (Fig. 10b) the difference pattern has travelled from around 150°W in the initial data to 120°W; it reaches 80°W by day 4 (Fig. 10c) and continues eastward during the next two days (Fig. 10d). The maxima increase only slightly from day 0 to day 2, but they are doubled by day 4. By day 6 they have doubled again and the differences have now grown so much that over the Atlantic the forecast synoptic situations were quite different.

This example demonstrates the rapidity with which analysis errors can propagate downstream and amplify almost exponentially with a doubling time of about 2 days, especially in baroclinically active regions.

High resolution experiment

The ECMWF limited area model (ELAM) was used to study the importance of horizontal resolution and orographic representation for forecasting Alpine cyclogenesis. It was found that a high resolution model is capable of giving an accurate and detailed forecast, provided the orographic representation is appropriate to the resolution. Having established this, experiments were carried out to investigate whether a high resolution operational model could predict the behaviour and structure of intense features, such as hurricanes, that are not topographically induced. The case chosen for this study was super-typhoon Tip which occurred over the northwest Pacific and reached its maximum intensity, with a surface pressure of about 870 mb, on 12 October 1979.

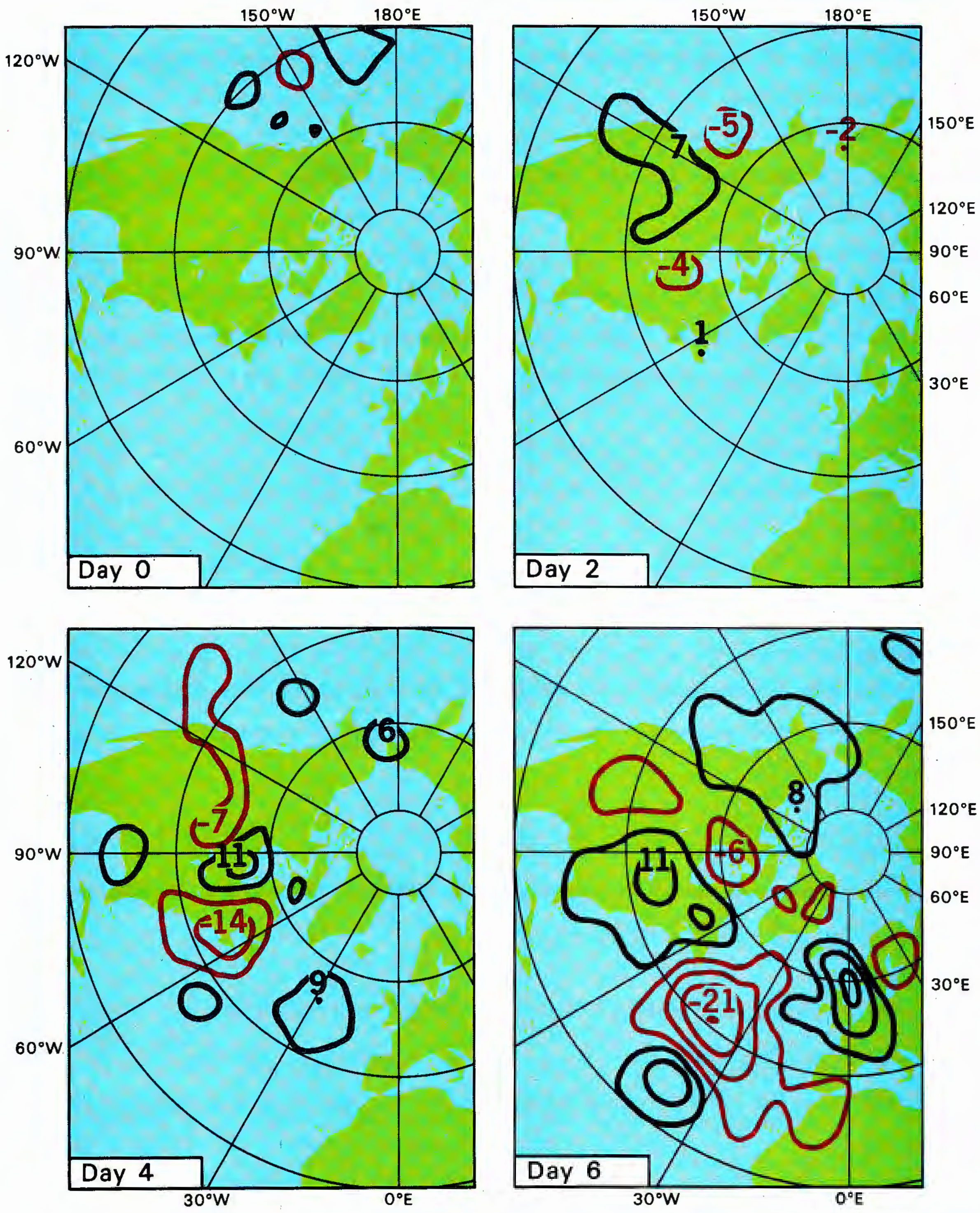


Fig. 10 Differences in the 300 mb height between forecasts with the ECMWF model using the ECMWF and the NMC analyses valid 00/00GMT 18 February 1979. Contour interval: 1 dam (negative-red; positive-black).

The experiments can be considered as operational forecasts because the ELAM had all the characteristics of the Centre's global model (without particular adaptation) and the boundary values were updated with forecast data from a three day global forecast interpolated to the N192 grid (about 0.47° of latitude and longitude).

The ELAM forecasts started at 00GMT 9 October 1979 when there was a large vortex in the western North Pacific with a minimum pressure of ~ 1005 mb. This tropical cyclone was observed to deepen rapidly during the next few days and develop the characteristics of a super-typhoon; the surface pressure dropped 59 mb in 27 hours and surface winds of 67 ms^{-1} were reported. The ELAM was able to reproduce the development of the typhoon, with a maximum drop in pressure of ~ 30 mb in 24 hours and surface winds of 40 ms^{-1}. By 0600GMT 12 October typhoon Tip reached its minimum pressure of 870 mb and maximum wind intensity of 85 ms^{-1}, whilst the simulated typhoon had a minimum pressure of ~ 945 mb and maximum winds in excess of 55 ms^{-1}. Since the ELAM forecast fields represent averages over a 50 x 50 km area, it is hardly surprising that the model was not able to reproduce the intensity of the development; however it certainly simulated a typhoon.

The structure of the simulated typhoon is illustrated by the vertical cross-sections of temperature anomaly and wind (Fig. 11a) and by the horizontal section of the wind field at 850 mb (Fig. 11b). Note the warm core, and the strong swirling round the 'eye' which are characteristic of tropical cyclones. It is also interesting to examine the structure of the rainfall. Fig. 12 shows the 24 accumulated rainfall from the 3 day forecast. As is often found in reality, there were two spiral rain bands with a maximum of rainfall near the core.

The experiment described here is just one of many that have been carried out to investigate the importance of resolution for accurate weather forecasting.

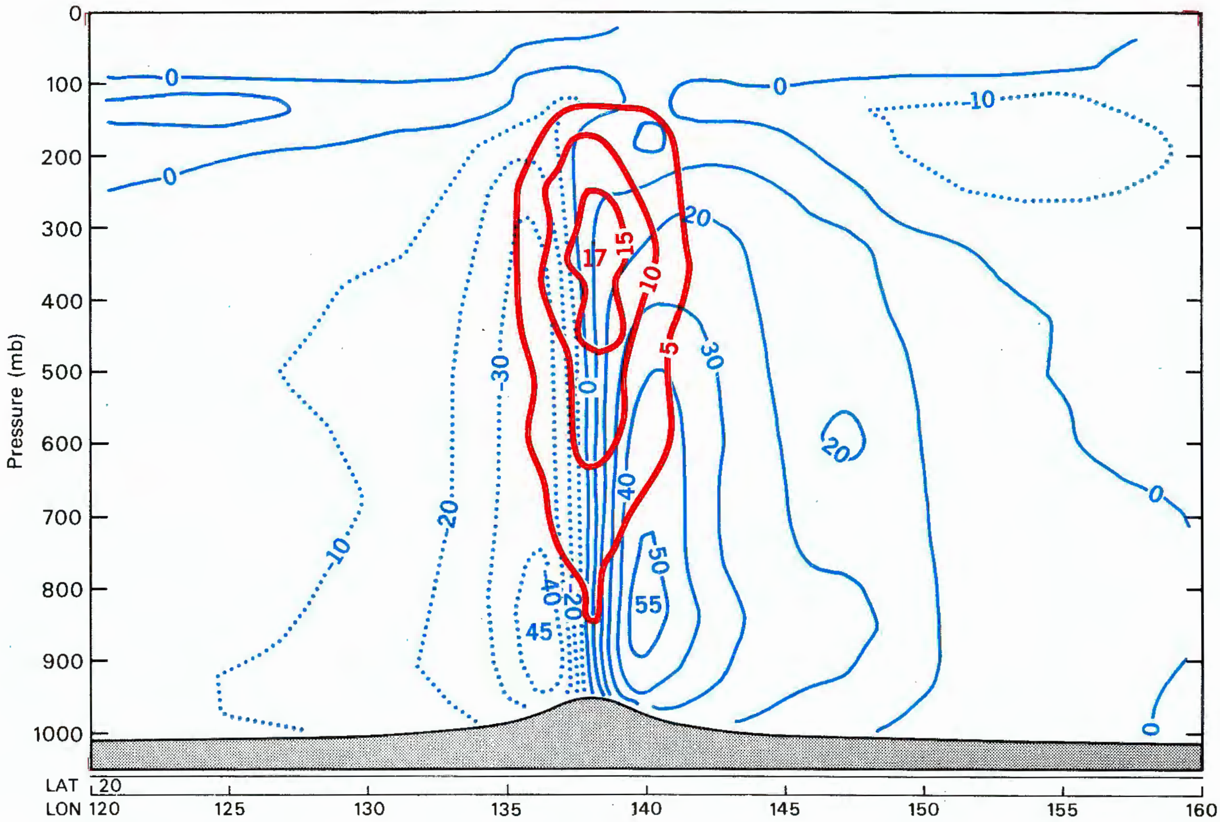


Fig. 11 a)

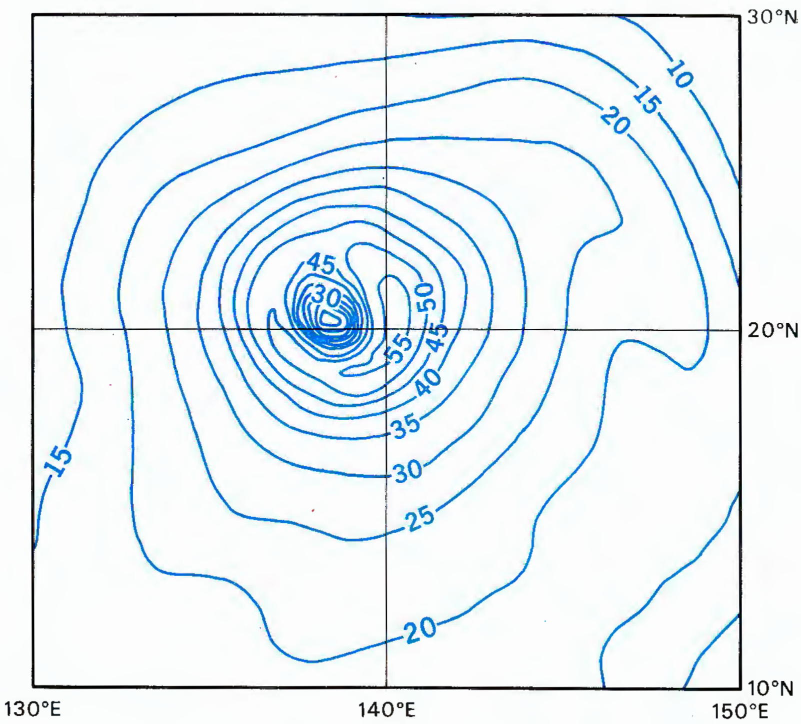


Fig. 11 b)

Fig. 11 a) *Vertical cross-section (120°E-160°E at 30°N) from day 3 of the forecast verifying at 0000GMT 12 October 1979. Blue lines are isotachs every 10ms*$^{-1}$ *of the wind perpendicular to the section (full lines-wind into the section; dashed lines-wind out of the section). Red lines are the potential temperature anomaly every 5K.*

Fig. 11 b) *Isotachs every 5ms*$^{-1}$ *of the horizontal wind at 850 mb.*

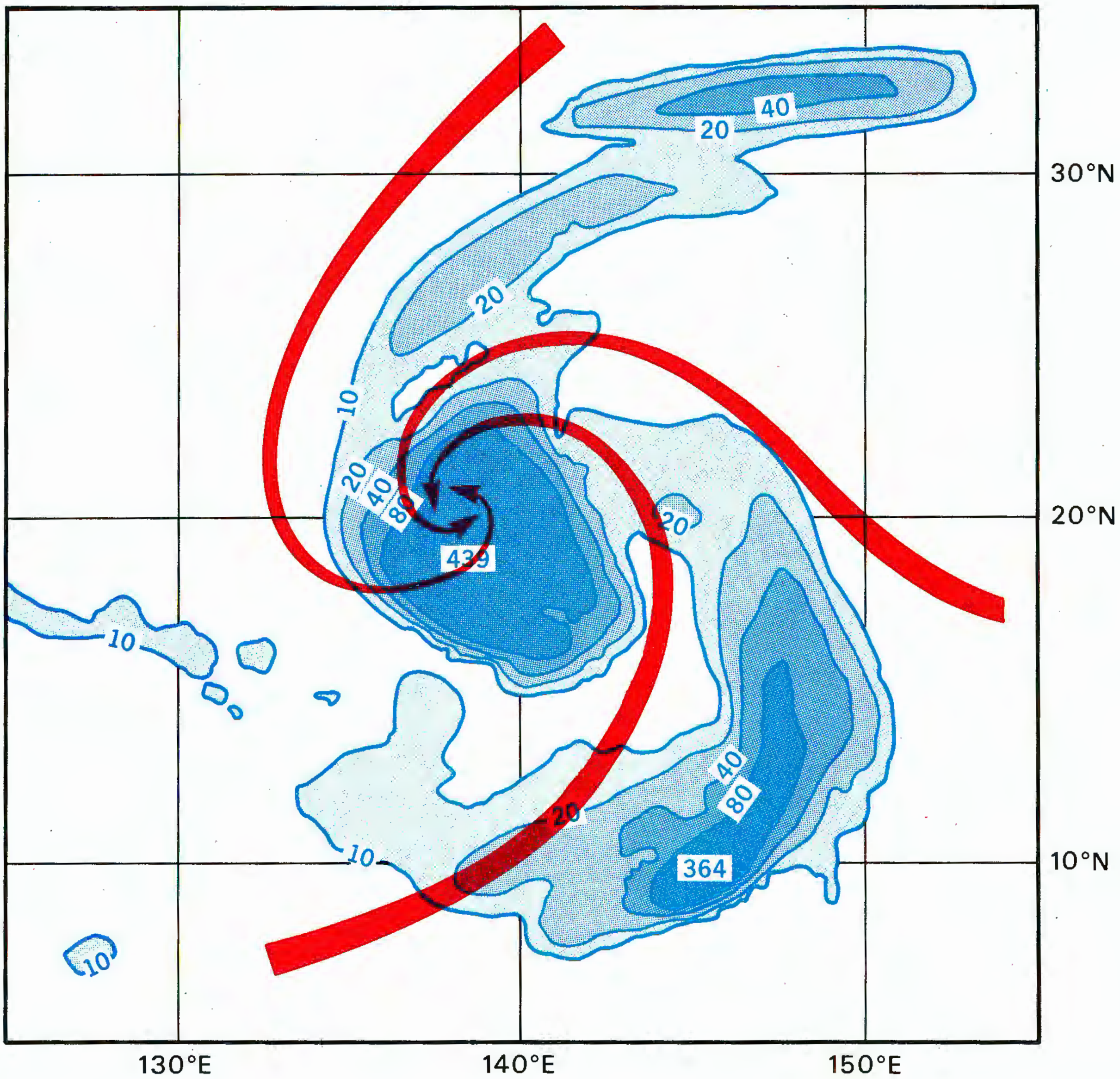


Fig. 12 24 hour accumulated precipitation during day 3 of the forecast ending 0000GMT 12 October 1979. Some 950 mb trajectories are shown in red.

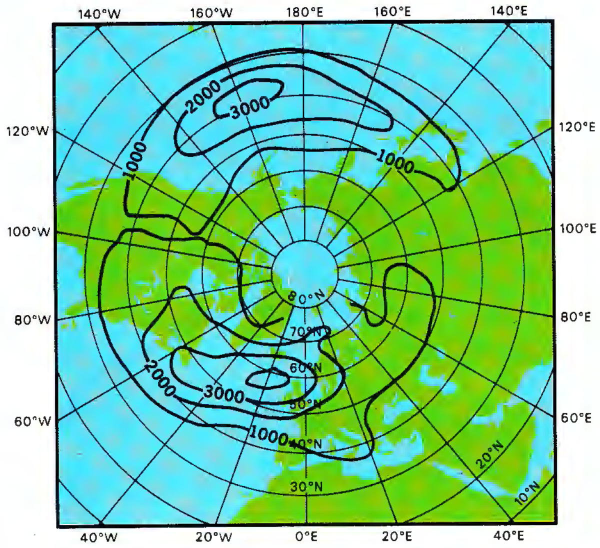


Fig. 13 Variance of the eastward travelling waves at 500 mb in the initialised analysis (period<3.3 days, all wavenumbers, winter 1982/83). Units: m^2

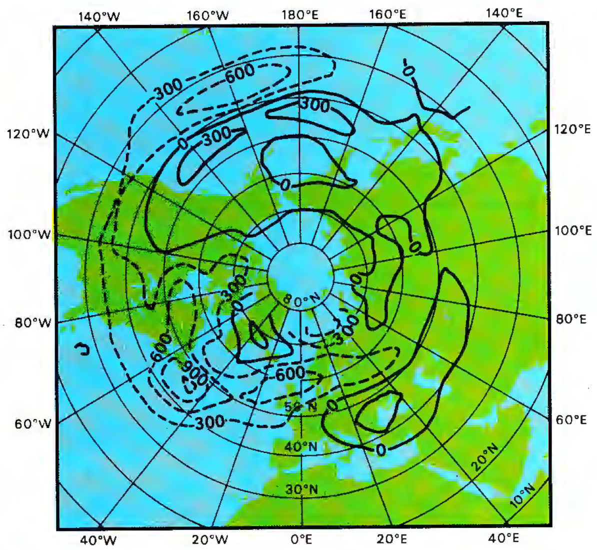


Fig. 14 Forecast error of the eastward travelling waves at 500 mb. (period<3.3 days, all wavenumbers, winter 1982/83). Units: m^2

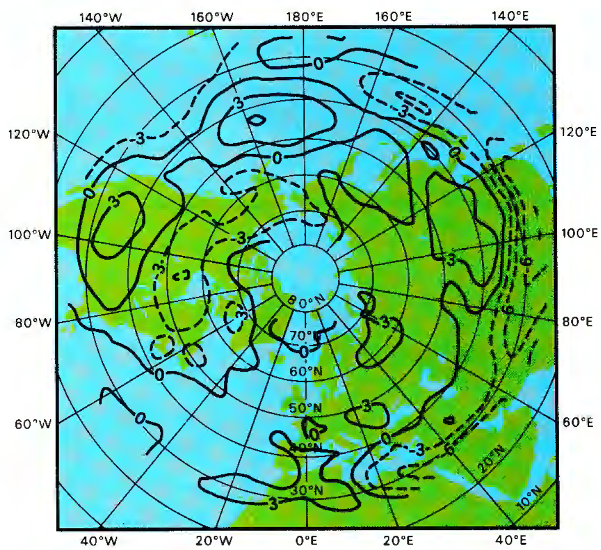


Fig. 15 Forecast error of the time mean vertical wind shear. Mean over 5 days of forecast minus analysis (winter 1982/83). Units: m^2s^{-1}

Errors in the model's baroclinic waves

Investigations of the forecast errors of the transient flow concentrated on studying the model errors of the fast baroclinic waves. For this purpose a wavenumber-frequency analysis was applied to a large number of forecasts and their corresponding verifying analyses.

The variance of eastward travelling waves with a period of less than 3.3 days in the 1982/83 winter (Fig. 13) showed two main storm tracks over the Pacific and Atlantic which are downstream of the major troughs in the 500 mb flow. The forecast error pattern for the same season (Fig. 14) indicated that in the Pacific there is a northward shift of the main baroclinic waves, whereas in the Atlantic there is an overall decrease in the activity of these waves. Similar results were found for the previous two winters.

Examination of the mean fields suggested that the weakening of baroclinic waves over the Atlantic is a response to differences in the mean state further upstream over North America. Here warming at high latitudes and cooling at about 35°N lead to a decrease in the baroclinicity of the mean flow; consequently the vertical wind shear decreases over a deep layer in the area where cyclonic development is initiated (Fig. 15). According to theory, the growth rate of baroclinic waves is proportional to vertical wind shear. Therefore it is expected that a reduction of the vertical wind shear over North America will cause a decrease in baroclinic wave activity downsteam over the Atlantic.

These results indicate that the primary cause of the deficiency of the baroclinic waves over the Atlantic appears to be the decrease in mean baroclinicity over North America. The reasons for this decrease must now be investigated.

EDUCATION

Seminar

The Seminar on "Numerical methods for weather prediction" was held at the Centre from 5-9 September and it attracted a large number of participants (excluding lecturers there were 45 participants from 14 Member States). During the Seminar lectures, covering the development of numerical methods during the last decade, were given by scientists who were responsible for many of the advances. They were complemented by other lectures which covered recent developments both in meteorology and the more general field of computational fluid dynamics. It was clear from the Seminar that much progress was still being made in this subject, and that some of the improvements in numerical weather prediction are due to the increased efficiency and accuracy of the numerical methods.

Workshop

A workshop was held on "Convection in large scale models" from 28 November to 1 December. The invited participants had a wide range of interests and this made it possible to consider many different aspects of the topic: the theoretical and observational basis of convection parameterization schemes, the impact of convection schemes on forecasts and the large scale dynamical response to tropical forcing. Following the formal presentations, working groups were set up to review the work that had been presented and made recommendations about where efforts should be placed in the future.

Meteorological training course

The object of the training course is to assist Member States in advanced training in the field of numerical weather forecasting. The course was divided into four modules and students could attend any combination of these. The first three modules were the concern of the Research Department and they dealt with the scientific basis and construction of numerical models, whilst the fourth module, run by the Operations Department, dealt with the use and interpretation of the Centre's products. In all, 25 people from 13 Member States attended various parts of the course; of these 17 were members of their National Meteorological Service.

Computer training course

These courses are designed to help both Member States and Centre staff become proficient at using ECMWF's extensive computer facilities. They assume knowledge of a computer system elsewhere, and then orientate users to the Cray and Cyber facilities. Two one-week courses were held at the Centre from 7 to 18 March, and 15 staff attended from 7 Member States. In addition a one week course was held at the Swedish Meteorological and Hydrological Institute from 7 to 11 November for some 10 staff. Individual tuition was also given to Member State visitors and Centre staff as the need arose.

Visits to meteorological services

It is planned that every two years each meteorological service of the Member States should be visited by a delegation from the Centre. The object is to give seminars on the operational and research activities at the Centre, and to discuss with the staff from the Member States their experience of using the Centre's products. During 1983 four countries were visited on such missions by joint delegations from the Operations and Research Departments; these were Austria, Italy, Spain and Portugal. The presentations were received with interest and the discussions proved useful to all concerned. It is hoped that these visits provide a useful two-way exchange of information between the providers and users of the ECMWF forecasts. Additionally, the German Weather Service (DWD) organised a three-day training course for forecasters from Austria, Germany and Switzerland who are involved in medium range weather forecasting. Staff from the Centre gave lectures about the ECMWF forecasting system and assisted in an assessment of the quality of the Centre's products.

PERSONNEL

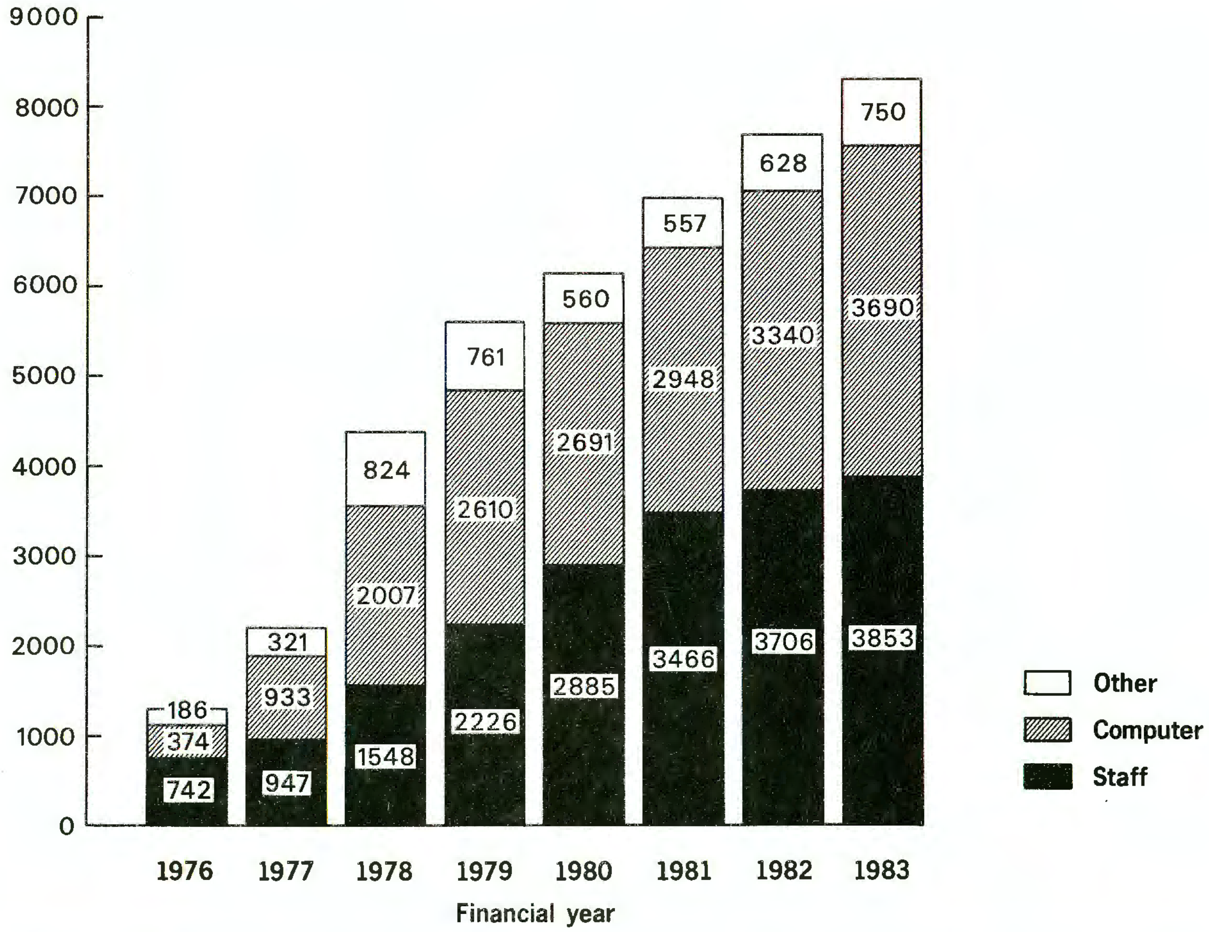
There are 142 posts authorised at the Centre, of which 137 were filled at 31 December 1983; additionally, 11 visiting scientists or consultants worked at the Centre during the year. Efforts continued to widen the geographical distribution of staff and by the end of 1983 sixteen Member States were represented at the Centre. Table 2 below shows the 1983 geographical distribution of staff. Thirteen staff members left the Centre during the year and two of the vacancies were filled internally.

Table 2 - Distribution of staff by categories and States

STATE	CATEGORY	hg	A	B	C	L	Total
Belgium			2				2
Denmark			4				4
Federal Republic of Germany			18	4		1	23
Spain				1			1
France			5	4		1	10
Greece			1				1
Ireland			4	1			5
Italy			5		1		6
Yugoslavia			2	1			3
The Netherlands			1	5			6
Austria			3				3
Portugal							
Switzerland				1			1
Finland			5	1			6
Sweden		1	2				3
Turkey			1				1
United Kingdom			22	35	5		62
TOTALS		1	75	53	6	2	137

FINANCE

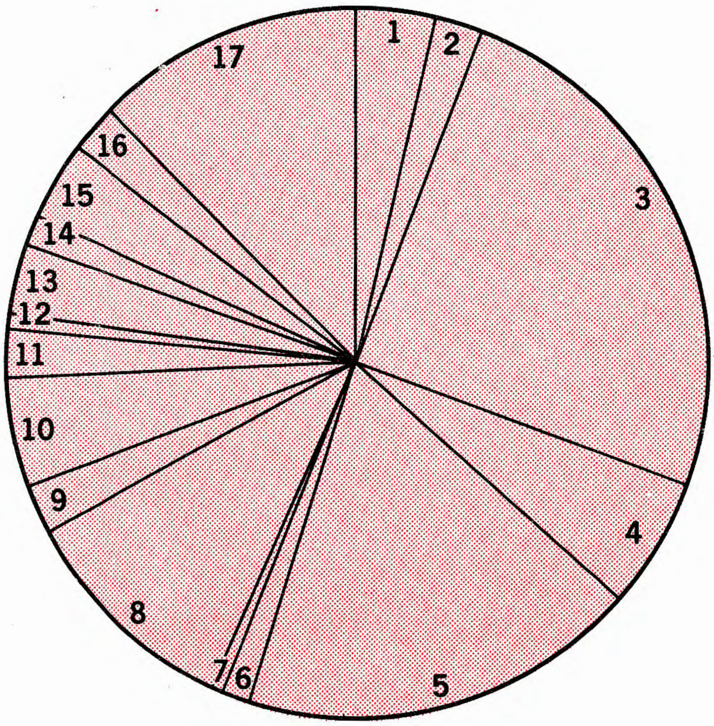
The Centre's Budget 1983 was adopted by the Council at its 16th session held on 18-19 November 1982. The approved total revenue and expenditure for the year 1983 was £8,603,600 - an increase of £562,000 (+6.99%) over the Budget 1982. The increase was due to salary adjustments and higher operating expenditure. The total expenditure was mainly met by the financial contributions of the Member States, to which are added the proceeds of taxation, staff contributions to the Pension Scheme, bank interest, and other miscellaneous revenue such as tax refunds, etc. Fig. 16 shows the total actual expenditure in each of the years 1976-1983 on staff, computer costs, and other expenditure.



Note· Figures revised for 1979-80 to include certain 'computer' expenditure previously included in 'Other'.

Fig. 16 Expenditure on staff, computer operations and other items during 1976-1983

The estimated Member States' contributions towards the 1983 Budget amounted to £7,441,700. Fig. 17 shows the percentage distribution of Member States' financial contributions in the period 1982-1984.



		%
1.	Belgium	3.62
2.	Denmark	2.16
3.	Germany	24.82
4.	Spain	5.96
5.	France	18.47
6.	Greece	1.27
7.	Ireland	0.46
8.	Italy	10.32
9.	Yugoslavia	2.25
10.	The Netherlands	4.96
11.	Austria	2.22
12.	Portugal	0.69
13.	Switzerland	3.22
14.	Finland	1.35
15.	Sweden	3.59
16.	Turkey	2.21
17.	United Kingdom	12.43

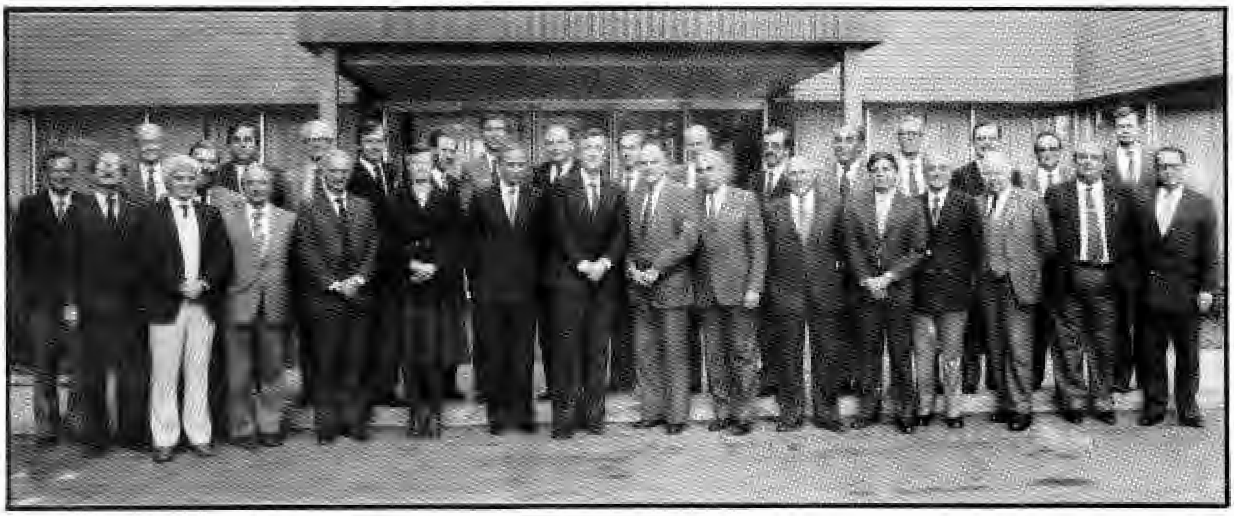
Fig. 17 Percentage distribution of Member States' contributions for 1982-1984

On 18 August 1983, the Centre signed an agreement with its bankers for the financing of the Cray X-MP, and the IBM 4341 data handling system. The transaction agreed with the Bank is for a bank overdraft supplemented by roll-over credit facilities. This means that the Centre will make use of its liquid funds when payment instalments on the equipment are due. As these funds are not, however, sufficient to cover the full purchase price of the equipment, it will be necessary to make use of the credit facilities agreed with the Centre's bankers. The overdraft and roll-over credit will be gradually repaid by the Member States over a period of five years. This is the largest financial transaction made to date by the Centre.

Signature of the agreement between ECMWF and Barclays Bank PLC for the financing of the acquisition of the CRAY X-MP and the IBM 4341 data handling system

l. to r.: Mr. H. Hartwig, Head of Administration Department, ECMWF; Dr. L. Bengtsson, Director, ECMWF; Mr. C. South, Manager, Bracknell Branch, Barclays Bank PLC; Dr. P. D'Ingeo, Head of Finance Section, ECMWF

THE COUNCIL, ITS COMMITTEES AND OTHER BODIES



Delegates at the 18th session of Council 23-24 November 1983, with the Director and some staff members of the Centre

The sessions and meetings of the Council, its Committees, and other bodies representing the Member States, held during 1983 were as follows:

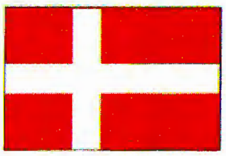
Council	17th and 18th sessions, 20-21 April and 23-24 November
Finance Committee	29th and 30th sessions, 23-25 March and 28-30 September
Scientific Advisory Committee	11th session, 12-14 September
Technical Advisory Committee	5th and 6th sessions, 21-22 March and 14-16 September
Computing Representatives	3rd meeting, 18-20 May.

The representatives of the Member States who attended meetings in 1983 are listed hereafter (code: C = Council; FC = Finance Committee; TAC = Technical Advisory Committee; CR = Computing representative; obs = observer). Also listed are the Meteorological Contact Points (MC).

Belgium

J. van Isacker (C); M. Deloz (FC obs.); W. Struylaert (TAC and CR); E. de Dycker (MC)

Denmark



L. Asmussen (C and FC obs.); Mrs. A.M. Jørgensen (TAC); P. Henning (CR); H. Voldborg (MC)

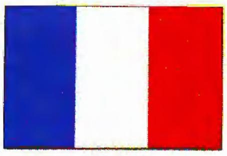
Federal Republic of Germany

E. Lingelbach (C: President); H.-G. Schulze (C); S. Schumm (C); U. Gärtner (C and FC); P. Appel (C and FC); W. Buschner (TAC); R. Lamp (TAC and CR); G. Stielow (MC)

Spain

P. Gonzalez-Haba (C); P. Rodriguez-Franco (C); M. Gonzalez-Blanch (FC); B. Orfila (TAC); M. Hortal (CR); R. Font Blasco (MC)

France

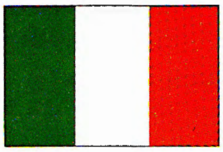


J. Labrousse (C); J. Lepas (C); J. Alt (C and FC); J.G. de Wargny (C); P. Cossevin (FC); M. Trochu (TAC and MC); L. Jouaillec (CR); J.P. Bourdette (CR)

Greece

S. Linardos (C); G. Barbounakis (TAC); D. Katsimardos (TAC); J. Iakovou (CR); A. Kakouros (MC); Mrs. M. Refene (MC)

Ireland



D.L. Linehan (C); W.H. Wann (TAC: Chairman); D. Murphy (CR); P.M.P. McHugh (MC)

Italy

A. Zancla (C); M. Mariani (C); A. Izzo (FC); G. de Florio (TAC and CR); M. Conte (MC)

Yugoslavia

I. Atimović (C); D. Radinović (C); M. Jovasević (TAC) M. Gavrilov (CR); S. Nicković (MC)

The Netherlands

J. van Tiel (C); Th. Voerman (C and FC obs); A.P.M. Baede (TAC: Vice-Chairman); J. van Dijk (CR); W.M. Reinten (MC)

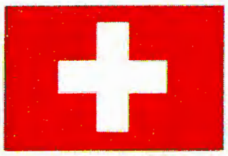
Austria

K. Cehak (C and FC: Vice-Chairman); G. Wihl (TAC and CR); H. Gmoser (MC)

Portugal

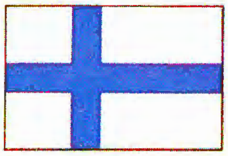
L.A. Mendes Victor (C: Vice-President); R.A.C. Carvalho (C); S. Cristina (TAC); M.J. Rodriguez de Almeida (CR); M.I.S.A. Barros Ferreira (MC)

Switzerland



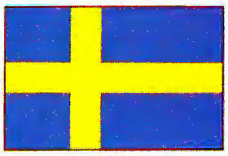
Th. Gutermann (C); H.P. Müller (FC obs); M. Haug (TAC)
G. Siegwart (CR); M. Schönbächler (MC)

Finland



E. Jatila (C); J. Paananen (FC); P. Nurminen (TAC);
T. Hopeakoski (CR); P. Kukkonen (MC)

Sweden

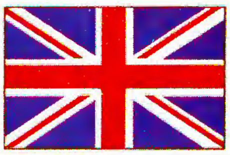


L. Ag (C); R. Berggren (C); C. Andersson (C);
L. Moen (TAC); G. Bleckert (TAC); S. Orrhagen (CR);
G. Salomonsson (MC)

Turkey

M.C. Ozgül (C, TAC, CR, MC); K. Oncüler (C)

United Kingdom



B.J. Mason (C); J.T. Houghton (C); G.J. Day (C and FC: Chairman); M.W. Stubbs (FC); K. Burford (FC);
D.H. Johnson (TAC); P. Ryder (TAC); R. Wiley (TAC);
A. Dickinson (CR); C. Flood (MC)

The members of the Scientific Advisory Committee, who are appointed in their personal capacity and not as national representatives, were:

F. Bushby - Chairman (UK); R. Bates (Ireland); E. Holopainen (Finland); B. Hoskins (U.K.); L. La Valle (Italy); B. Machenhauer (Denmark); J. Peixoto (Portugal); H. Pichler (Austria); H. Reiser (Federal Republic of Germany); R. Sadourny (France); C.J. Schuurmans (the Netherlands); H. Sundqvist (Sweden).

CONSULTANTS AND VISITING SCIENTISTS

The Centre received many visits in the course of the year, from consultants, experts and visiting scientists, whose expertise was drawn upon to augment the range and efficiency of the work done at the Centre. Some visitors devoted an hour or two at the Centre to giving lectures to staff, others stayed for several months to tackle particular problems. It is impossible to list all those who have contributed in such a way to the Centre's work; however, the most notable projects carried out, and those who worked on them, are the following:

Dr. A.K. Betts
West Pawlet, Vermont, USA
Investigating a new approach for convection schemes based on saturation point adjustment.

Dr. Chen Shou-Jun
Dept. of Geophysics, Peking University, Beijing, China
Studied the impact of the Tibetan plateau on the large scale flow and investigated synoptic and meso-scale disturbances over China using the limited area model.

Dr. R. Daley
National Center for Atmospheric Research, Boulder, Colorado, USA
Studied a series of theoretical problems relating to the analysis system, including the spectral response properties, the analysis of divergence and the analysis of the large scale tropical wind field.

Mr. M. Gleicher
(Contract started on 1 December 1983)
Work was started in the provision of an interface in connection with the CFS (Common File System) for use in development of the Centre's archives.

Dr. J. Hamilton

Meteorological Service, Dublin, Ireland

A users specification for a command-driven graphics package was developed, and a portable version of a command processor was implemented.

Mr. E. Hellsten

Creation of a global analysis data set and a global observational data set for the period 1980-1982 was begun.

Dr. M. Manton

CSIRO, Sydney, Australia

Developed and tested a new boundary layer formulation for global models which emphasised the representation of turbulent processes related to boundary layer cloudiness.

Dr. M. Miller and Dr. M. Moncrieff

Imperial College, London, UK

Continued the development of a new parameterization scheme for convection which is based on dynamical models of convective systems.

Mr. A. Persson

SMHI, Norrköping, Sweden

Development of presentation of numerical guidance for medium range weather forecasts using time averaged and spectrally filtered model output was investigated.

Prof. D. Radinović

Dept. of Meteorology, University of Belgrade, Yugoslavia

Worked on ALPEX data and designed a new method of representing orography in large scale models which has been tested in both limited area models and global simulations.

Mr. T. Raggett

(Contract started 12 December 1983)

Assistance in the implementation and running of the Centre's IBM system was provided; work commenced on the design of routines in connection with implementation of CFS (Common File System) on the IBM.

Dr. A. Sutera

Yale University, Hartford, Connecticut, USA

Investigated the predictability of blocked atmospheric states and the relationship between deep cyclogenesis and the onset of blocking.

Dr. J. Thiebaux

Dalhausie University, Halifax, Canada

Consulted with the analysis group on the theoretical basis for the formulation of the horizontal and vertical structure functions in the analyses formulation.

Dr. Wu Guo-Ziong

Inst. of Atmospheric Physics, Chinese Academy of Sciences, Peking, China.

Studied the effect of large-scale orographic and thermal forcing on the time meaned zonally averaged meridional circulation and the associated heat and momentum transports.

ANNEX 1

ECMWF publications 1983

Technical reports

No.35	Oriol, E.	ENERGY BUDGET CALCULATIONS AT ECMWF PART 1: ANALYSIS 1980-81
No.36	Nieminen, R.	OPERATIONAL VERIFICATION OF ECMWF FORECAST FIELDS AND RESULTS FOR 1980-1981
No.37	Dell'Osso, L.	HIGH RESOLUTION EXPERIMENTS WITH THE ECMWF MODEL. A CASE STUDY
No.38	Cubasch, U.	THE RESPONSE OF THE ECMWF GLOBAL MODEL TO THE EL NIÑO ANOMALY IN EXTENDED RANGE PREDICTION EXPERIMENTS
No.39	Manton, M.J.	ON THE PARAMETERIZATION OF VERTICAL DIFFUSION IN LARGE-SCALE ATMOSPHERIC MODELS

Seminar/workshop proceedings

INTERPRETATION OF NUMERICAL WEATHER PREDICTION PRODUCTS

Seminar 13-17 September 1982

Workshop 20-24 September 1982

INTERCOMPARISON OF LARGE-SCALE MODELS USED FOR EXTENDED RANGE FORECASTS

Workshop 30 June - 2 July 1982

Manuals

Research Manual 1. ECMWF DATA ASSIMILATION SCIENTIFIC DOCUMENTATION
Ed. by P. Lönnberg and D. Shaw

Meteorological Bulletin M1.5/1

The Centre also continued to publish regular issues of the ECMWF Newsletter, Computer Bulletins, Forecast Reports, Meteorological Bulletins, and the Operational Data Assimilation System-Daily Global Analysis.

ANNEX 2

External publications by members of staff 1983

Arpe, K. and Wallace, J.M.	TROPICAL PACIFIC SEA-SURFACE TEMPERATURE ANOMALY EXPERIMENTS WITH THE ECMWF MEDIUM RANGE FORECAST MODEL. Proceedings 7th Annual Climate Diagnostics Workshop, NOAA, 1982, 340-348.
Bengtsson, L.	OBSERVATIONAL REQUIREMENTS FOR LONG-RANGE FORECASTING. WMO, Long-Range forec.res.publ.ser.1, 219-229.
Bengtsson, L.	RESULTS OF THE GLOBAL WEATHER EXPERIMENT. Results of the global weather experiment. WMO-No.610, 2-40.
Bengtsson, L. and Lighthill, J. (Ed.)	INTENSE ATMOSPHERIC VORTICES. Proceedings. Springer Verlag, 326 pp.
Bengtsson, L. and *Simmons, A.J.*	MEDIUM RANGE WEATHER PREDICTION - OPERATIONAL EXPERIENCE AT ECMWF. Large scale dynamical processes in the atmosphere, ed. by B. Hoskins and R. Pearce, Academic Press, 337-364.
Cats, G.J. and *Åkesson, O.*	AN INVESTIGATION INTO A MARKED DIFFERENCE BETWEEN TWO SUCCESSIVE ECMWF FORECASTS OF SEPTEMBER 1982. Contrib.Atm.Phys., 56, 440-451.
Geleyn, J.F. and Preuss, H.J.	A NEW SET OF SATELLITE DERIVED SURFACE ALBEDO VALUES FOR OPERATIONAL USE AT ECMWF. Arch.Met., Geoph. and Bioclim., Ser.A, 32, 353-359.
Hoffmann, G.R.	DIE ENTWICKLUNG DER RECHNERKONFIGURATION IN EZMW. Betrieb von DV Systemen in der Zunkunft, 5.G1. Fachgespräch über Rechnerzentren, 1983, Graef Verlag, 176-186.

Hollingsworth, A., Kållberg, P., Renner, V. and *Burridge, D.M.* — AN INTERNAL SYMMETRIC COMPUTATIONAL INSTABILITY. Q.J.Roy.Met. Soc., 109, 417-428.

Ji, L.R., and Tibaldi, S. — NUMERICAL SIMULATIONS OF A CASE OF BLOCKING: THE EFFECTS OF OROGRAPHY AND LAND-SEA CONTRAST. Mon.Wea.Rev., 111, 2068-2086.

Louis, J.-F., Weill, A., and Vidal-Madjar, D. — DISSIPATION LENGTH IN STABLE LAYERS. Bound.Layer Meteor., 25, 229-243.

Scarani, C., Tampieri, F., and *Tibaldi, S.* — THE EFFECTS OF HIGH RESOLUTION OROGRAPHY ON NUMERICAL MODELLING OF ATMOSPHERIC FLOW: A PRELIMINARY EXPERIMENT. Il nuovo cimento, 6C, 179-201.

Shaw, D.B. — ECMWF'S EXPERIENCE OF DATA ASSIMILATION AND MEDIUM RANGE PREDICTION FOR THE SOUTHERN HEMISPHERE. 1st International conference on Southern Hemisphere meteorology, 1983, AMS, 175-179.

Simmons, A.J. — DYNAMICAL PREDICTION: SOME RESULTS FROM OPERATIONAL FORECASTING AND RESEARCH EXPERIMENTS AT ECMWF. WMO, Long-range forec. res.publ.ser.1, 187-206.

Simmons, A.J. and *Strüfing, R.* — NUMERICAL FORECASTS OF STRATOSPHERIC WARMING EVENTS USING A MODEL WITH A HYBRID VERTICAL COORDINATE. Q.J.Roy.Met.Soc., 109, 81-111.

Simmons, A.J., Wallace, J.M. and Branstator, G.W. — BAROTROPIC WAVE PROPAGATION AND INSTABILITY, AND ATMOSPHERIC TELECONNECTION PATTERNS. J.Atmos.Sc., 40, 1363-1392.

Tibaldi, S. — ON THE RELATIONSHIP BETWEEN THE SYSTEMATIC ERROR OF THE ECMWF FORECAST MODEL AND OROGRAPHIC FORCING. Workshop on Predictability of fluid motions, 1983, American Inst.of Physics, 21 pp.

Tibaldi, S. and Buzzi, A. — EFFECTS OF OROGRAPHY ON MEDITERRANEAN LEE CYCLOGENESIS AND ITS RELATIONSHIP TO EUROPEAN BLOCKING. Tellus, 35A, 269-286.

Tibaldi, S. and *Ji, L.R.* — ON THE EFFECTS OF MODEL RESOLUTION ON NUMERICAL SIMULATION OF BLOCKING. Tellus, 35A, 28-38.

Volmer, J.P., Dégué, M., and *Jarraud, M.* — LARGE-SCALE FLUCTUATIONS ON A LONG-RANGE INTERGRATION OF THE ECMWF SPECTRAL MODEL. Tellus, 35A, 173-188.

Wallace, J.M., *Tibaldi, S.*, and *Simmons, A.J.* — REDUCTION OF SYSTEMATIC FORECAST ERRORS IN THE ECMWF MODEL THROUGH THE INTRODUCTION OF AN ENVELOPE OROGRAPHY. Q.J. Roy.Met.Soc., 109, 683-717.