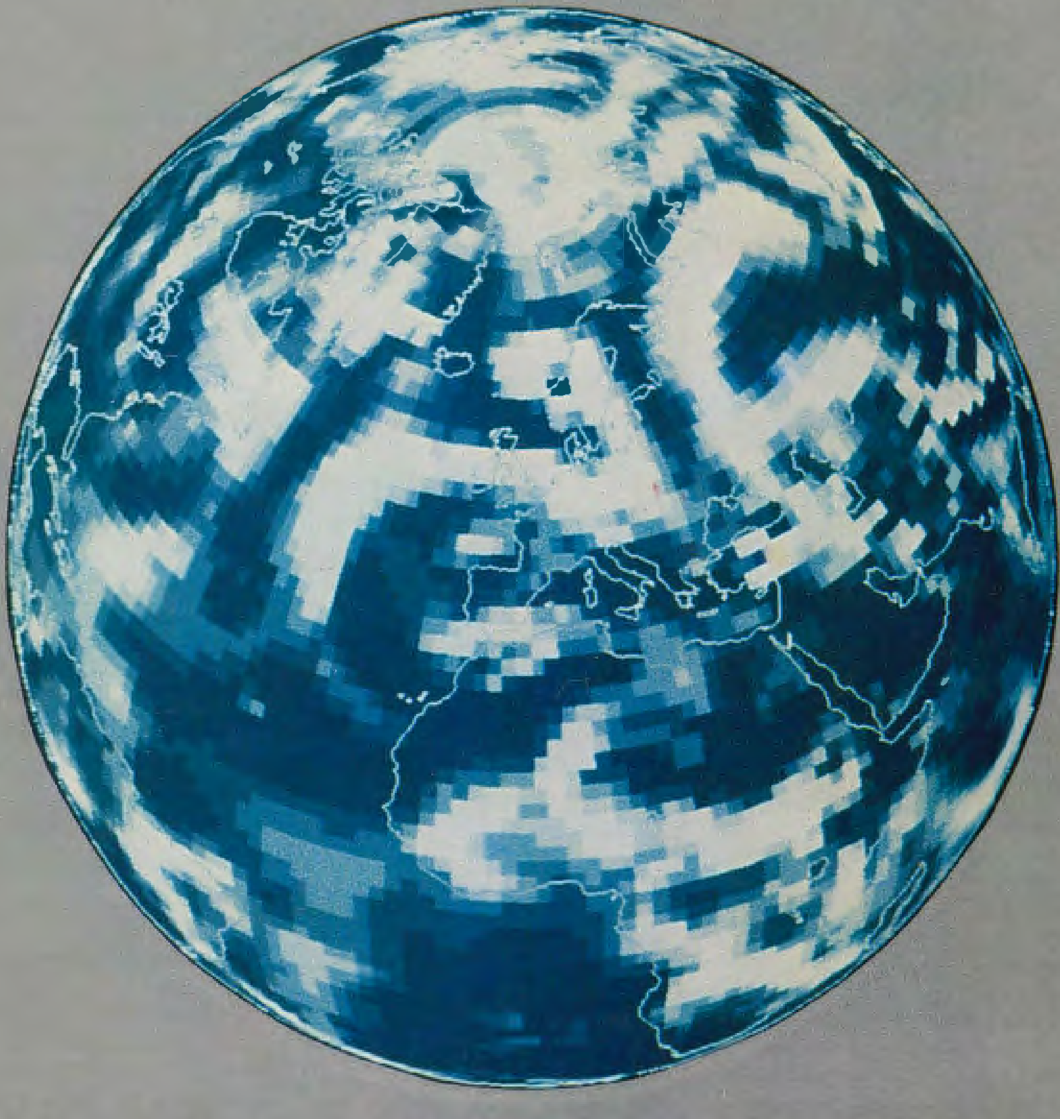
Annual Report 1982



European Centre for Medium Range
Weather Forecasts

Annual Report 1982

Presented to the Council by the Director,

Dr. L. Bengtsson

European Centre for Medium Range
Weather Forecasts

Contents

Foreword

It gives me great satisfaction to contribute to the Annual Report for a year in which the faith placed in the Centre by its Member States has been so well justified by the successful outcome of its work.

At the Council session held in November 1982, we heard that the Centre's products are now widely used within the Member States as the basis, and in many cases the only basis, for their medium-range forecasts. In addition many non-Member States use the Centre's products distributed free on the Global Telecommunications System of the World Meteorological Organisation for the same purpose. It was particularly interesting to note that following a trial period in two regions of China, a decision has been made to use the Centre's products for the preparation of medium-range forecasts in those regions.

It has been agreed world-wide that the Centre's forecasting model is the best model available at present, and the staff of the Centre must be congratulated on this achievement. Appreciation must also be shown for the unremitting endeavours to improve on the model. I am sure that by the time the change is made to a spectral version of the model, which we look forward to in 1983, the results will be even more impressive.

On a personal note, I am very happy to have been re-elected to serve as President of the Council for a further year, since this will enable me to continue a close and fruitful association with the work of the Centre.

Lastly, I would like to express my thanks to all my colleagues in the Council and its Committees, to the Director of the Centre, Dr. Bengtsson and to the staff of the Centre for all their efforts in 1982.

I am sure that the success during the past years and the planned technical installation will give the Centre the impetus to progress further and to keep its outstanding position, firstly to the benefit of all Member States and finally to the advantage of all the Nations of the world.

Dr. E. Lingelbach

Introduction

1982 has been a creative and active year at the Centre. The scientific work has provided us with a much deeper understanding of the dynamical and physical mechanisms of the large-scale processes of the atmosphere and their importance for forecasting in the medium-range. Theoretical studies of atmospheric predictability at the Centre have demonstrated that further improvements of medium-range forecasts are possible even with the limitations of the present observing systems. It has been estimated that the range of useful forecasts can be extended, at least in principle, by another 3-4 days. Scientific studies have also indicated that the systematic errors of the model are due, to a significant extent, to an insufficient forcing from the large-scale orography.

The result of the scientific studies has been incorporated in the new forecasting model due for operational implementation early in 1983. A modified representation of the model's orography representing an envelope over and around the mountains has been successfully tested and has led to a significant reduction of the prediction errors.

The observations from FGGE have been studied in observing system experiments. Preliminary results have demonstrated the importance of accurate observations for medium-range prediction. Of particular importance are observations from satellites and aircraft which complement the radiosonde network in a very important way, being available in data-sparse areas over the oceans.

The operational forecasts have continued to improve although less during 1982 than 1981. The services provided to the Member States have been significantly expanded and a large variety of products from the model is now available for different applications in the Member States.

It has been very gratifying to learn that a special WMO study has shown that the Centre's forecasts are the best available.

The forecasts disseminated on the Global Telecommunications System (GTS) were extended during the year to include forecasts for the tropical belt. The forecasts sent out on the GTS which now cover the whole earth are widely used operationally, and successful operational applications have been reported from many countries including China, Australia and New Zealand.

The Centre's computer system was enhanced and a second front-end computer, the Control Data Cyber 835 was accepted early in the year. A powerful mini-computer, the VAX 11/750, was incorporated in the Centre's computer system at the end of the year, and will be used for graphical applications.

The Director and the staff have enjoyed a good and constructive co-operation throughout the year. The excellent contribution made by the staff to a successful 1982 is very much appreciated.

Lennart Bengtsson

Operations Department

Forecasts to ten days ahead were produced daily during the year, with no forecasts lost and with few delays. Member States are using more ECMWF products for more applications. A seminar and workshop were held to assist Member States to interpret the Centre's numerical forecasts. More non-Member States have reported on their use of those ECMWF forecasts which are distributed on the Global Telecommunications System. The European Space Agency has begun to use the Centre's forecasts in the derivation of satellite wind data from Meteosat.

The Centre's computer system has been augmented during the year, notably by the addition of a second front-end computer in January and a minicomputer for graphics in December.

Operational Forecasting

The primary task of the Operations Department is the reliable production and dissemination of operational medium-range weather forecast products. Figure 1 shows actual timings of the operational suite runs on the CRAY-1 computer during the month of June 1982, when the 1800GMT, 0000GMT and 0600GMT data assimilation cycles were run between 1700GMT and 2000GMT while the final 1200GMT cycle, with a 2045GMT data cut-off time, started within minutes of 2100GMT. The 10-day forecast was completed before 0200GMT on each day of June. Delays in production of the forecasts were recorded in other months, associated at times with hardware problems. In September and October delays were caused by the necessity to reduce the time-step of the forecast from its normal 15 minutes to 12 minutes and eventually, for a short period in the beginning of October, to 10 minutes, to avoid numerical instability. The reason for this was the high wind speeds observed in the Southern Hemisphere stratosphere. In the first six months of the year only two forecasts were delayed in completion until after 0400GMT, while in the second half of the year fifteen forecasts were delayed until after 0400GMT.

Efforts to improve the quality and coverage of the global data received at the Centre continued during the year. Considerable effort was put into systematic monitoring of incoming observational data; action was taken where possible to inform the appropriate authorities of defects which were detected. In common with other centres, ECMWF experienced many problems associated with the change to the new common code for surface observations on 1 January 1982. Important faults and deficiencies were detected in some radiosonde and satellite observations. These were brought to the attention of the appropriate organisations, such as the World Weather Watch Department of the World Meteorological Organisation, the National Meteorological Center, Washington, the National Environmental Satellite Service, USA and other centres.

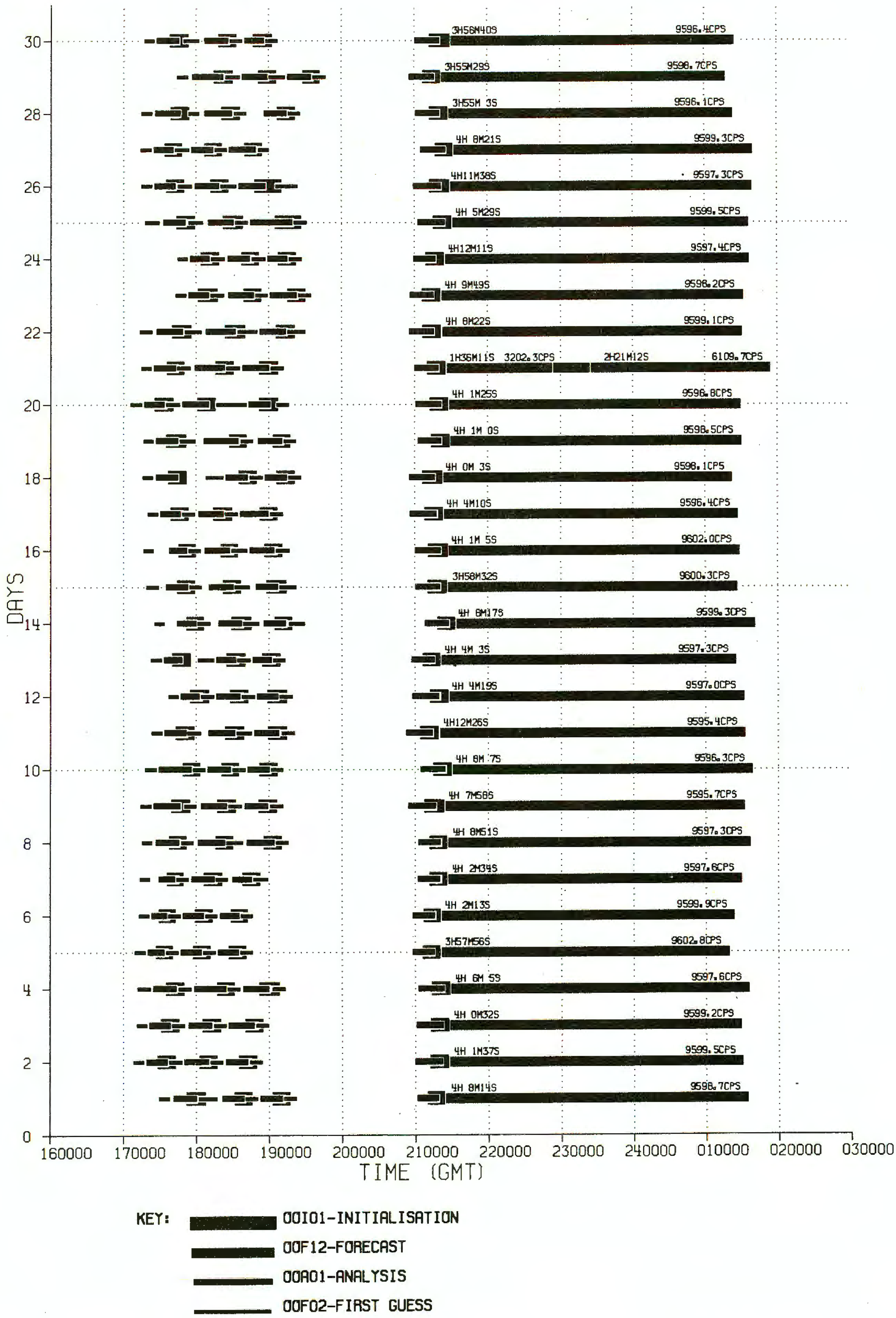


Fig. 1 Timings of the operational suite runs on the CRAY-1 during June 1982.

Use of ECMWF Forecasts

The number of forecast products disseminated each day to Member States increased from under 7,000 at the beginning of the year to over 8,000 in December. The number disseminated to individual Member States varied widely. Six Member States were regularly receiving forecasts up to ten days. A limited range of products, including forecasts for the Northern Hemisphere (up to five days) for the Southern Hemisphere (up to four days) and for the tropics (up to two days) are disseminated on the Global Telecommunications System. The dissemination of the tropical forecasts started on 1 July 1982. ECMWF products are in daily operational use in many countries, including China, India, Australia, New Zealand and the United States. The products are, in many cases, distributed to regional and local level via internal facsimile circuits, after being decoded and plotted at the National Meteorological Centre of the country. Assessments of forecast quality and systematic errors are being received and studied by the Centre.

Since October 1982, the European Space Agency has been using ECMWF products (including forecasts of temperature and humidity) operationally in their processing of meteorological data from Meteosat.

Assessment and Verification of the Centre's Forecasts

Objective assessment of the Centre's forecasts is carried out for several areas, including hemispheric and regional domains, using conventional verification scores. Figures 2 and 3 show, for 500 and 1000 mb, the anomaly correlation scores and the standard deviations of the errors for the three to six day forecasts of the geopotential height over the European area from January 1980 to December 1982. Seasonal fluctuations in the scores are removed by computing 12-month running mean scores.

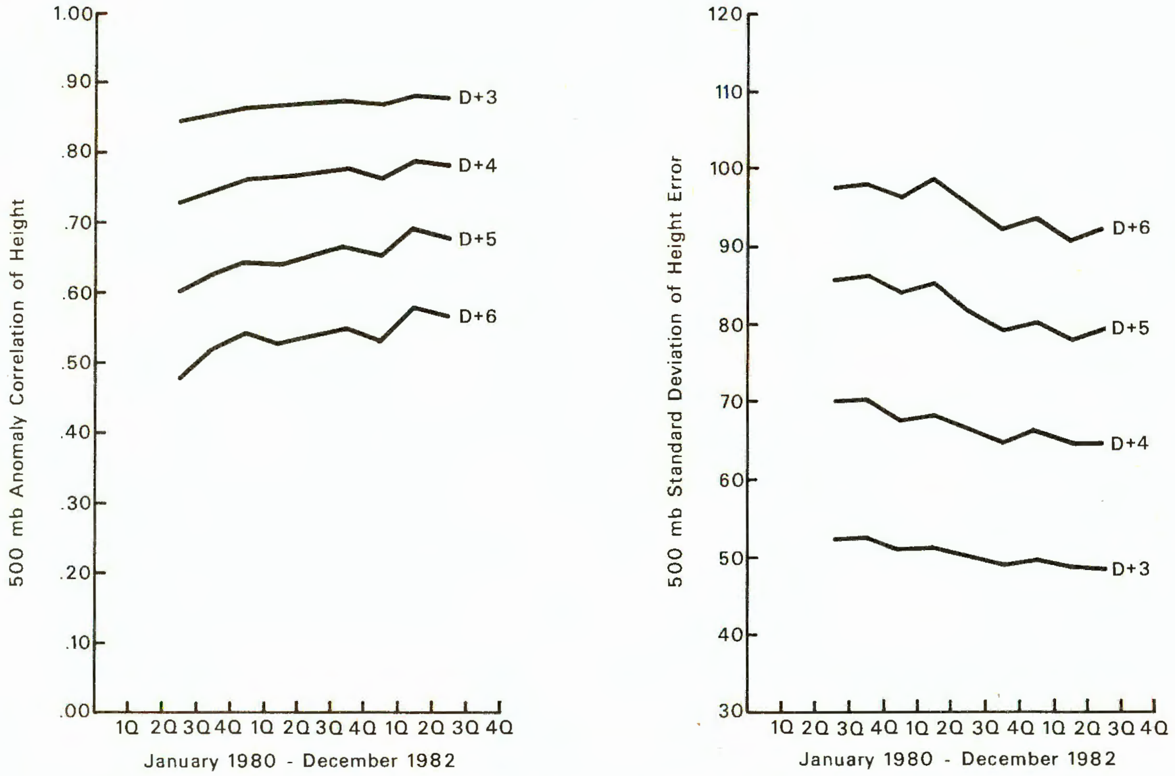


Fig. 2 500 mb anomaly correlation scores and standard deviations of geopotential height errors of 3-6 day forecasts over Europe, January 1980 - December 1982.

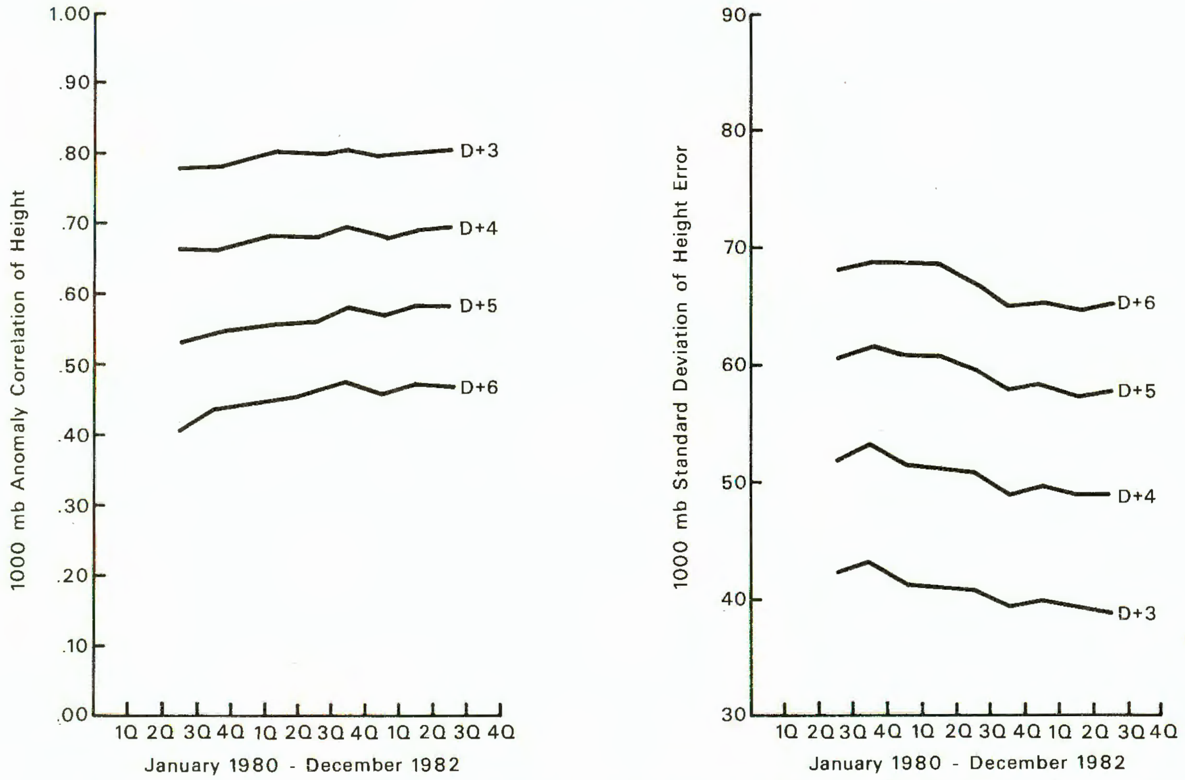


Fig. 3 1000 mb anomaly correlation scores and standard deviations of geopotential height errors of 3-6 day forecasts over Europe, January 1980 - December 1982.

At 500 mb, for example, the anomaly correlation coefficient for 5-day forecasts has increased from 0.6 to almost 0.7 during the period and the 6-day score from below 0.5 to nearly 0.6. A steady reduction in the forecast errors is also evident for all forecast days, with the larger gains in forecast accuracy being achieved in the longer range forecasts.

In July 1982, the Centre began to disseminate 850 and 200 mb wind forecasts for the tropics up to two days. Figures 4 and 5 show, for each day of the months September-October, the absolute correlation coefficient and root mean square errors of the vector wind at the 850 and 200 mb levels for both 1981 and 1982. Shading is used to emphasise those periods when the 1982 forecasts improved on those of 1981. The improvements can be associated with modifications made to the forecast model, including changed surface fluxes in January, the introduction of analysed sea surface temperatures in July and diabatic initialization in September.

Figure 6 shows the root mean square error of the 200 mb vector wind for the forecasts of 1982 and for persistence for the Northern Hemisphere (Figure 6a), the tropical belt (Figure 6b) and the Southern Hemisphere (Figure 6c). For both extratropical areas, the forecast shows significantly higher scores than persistence for all ten days of the forecast, while in the tropics persistence is better beyond six and a half days.

Figure 7 shows the 12-month running mean root mean square of the standard deviation of the forecast error of the three-day forecasts for the Northern Hemisphere. The ECMWF score is shown, as is the average score for the four forecast centres: Deutscher Wetterdienst, French National Meteorological Service, National Meteorological Center (USA), and the United Kingdom Meteorological Office. Both curves indicate improved forecast quality with time, but the continuing superiority of the ECMWF forecast is evident.

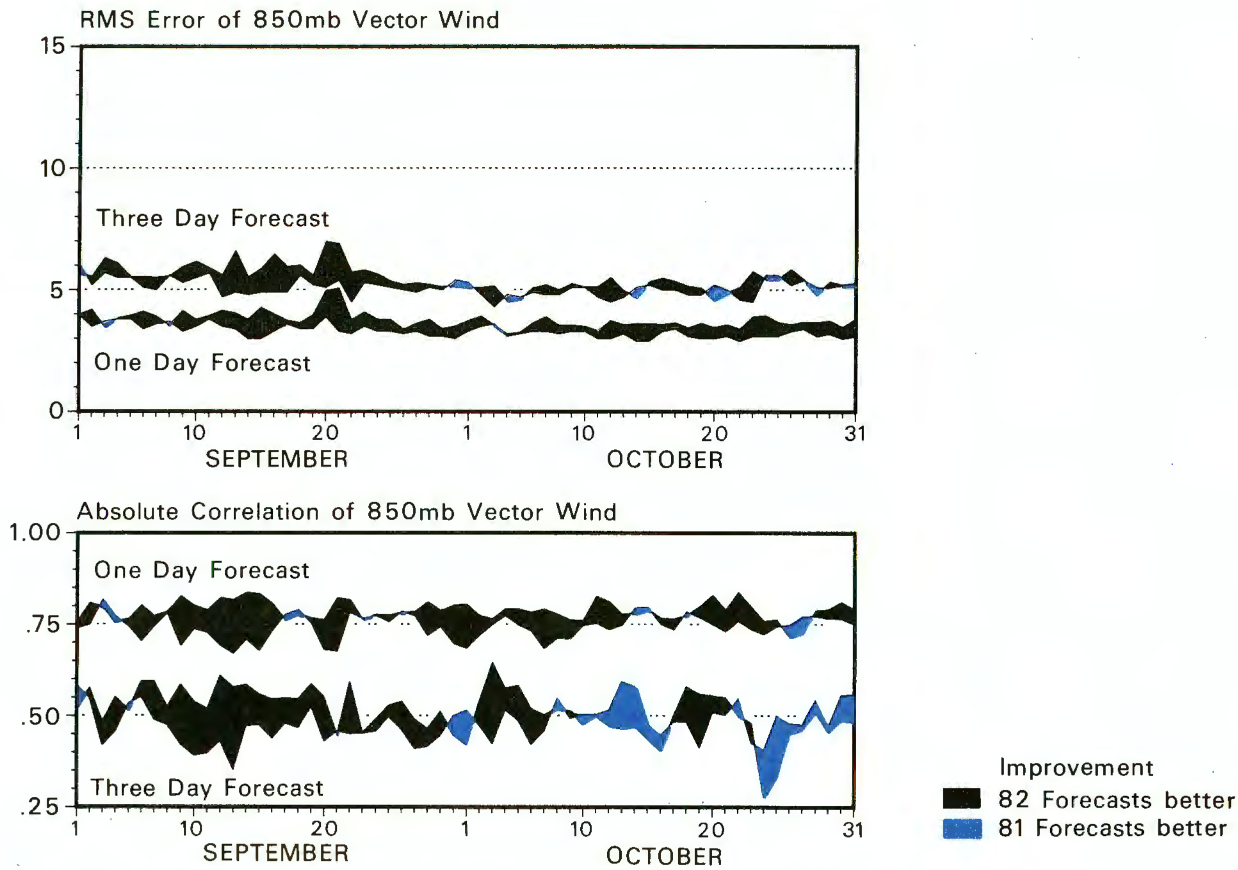


Fig. 4 Absolute correlation coefficient and root mean square errors of the vector wind at 850 mb, September-October 1981 and 1982.

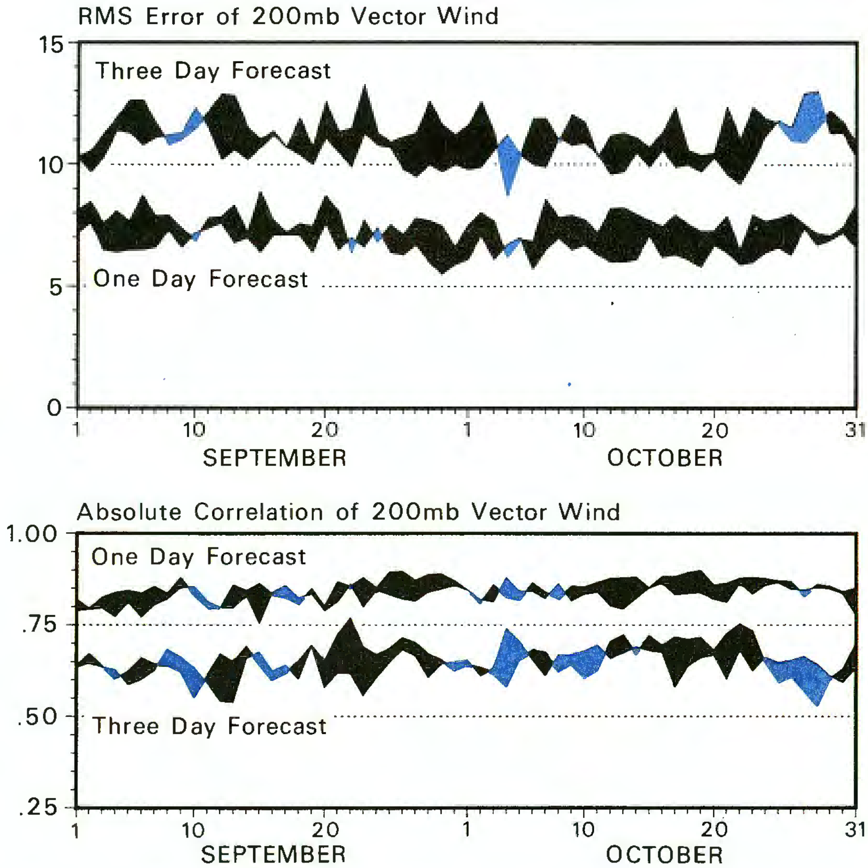


Fig. 5 Absolute correlation coefficient and root mean square errors of the vector wind at 200 mb, September-October 1981 and 1982.

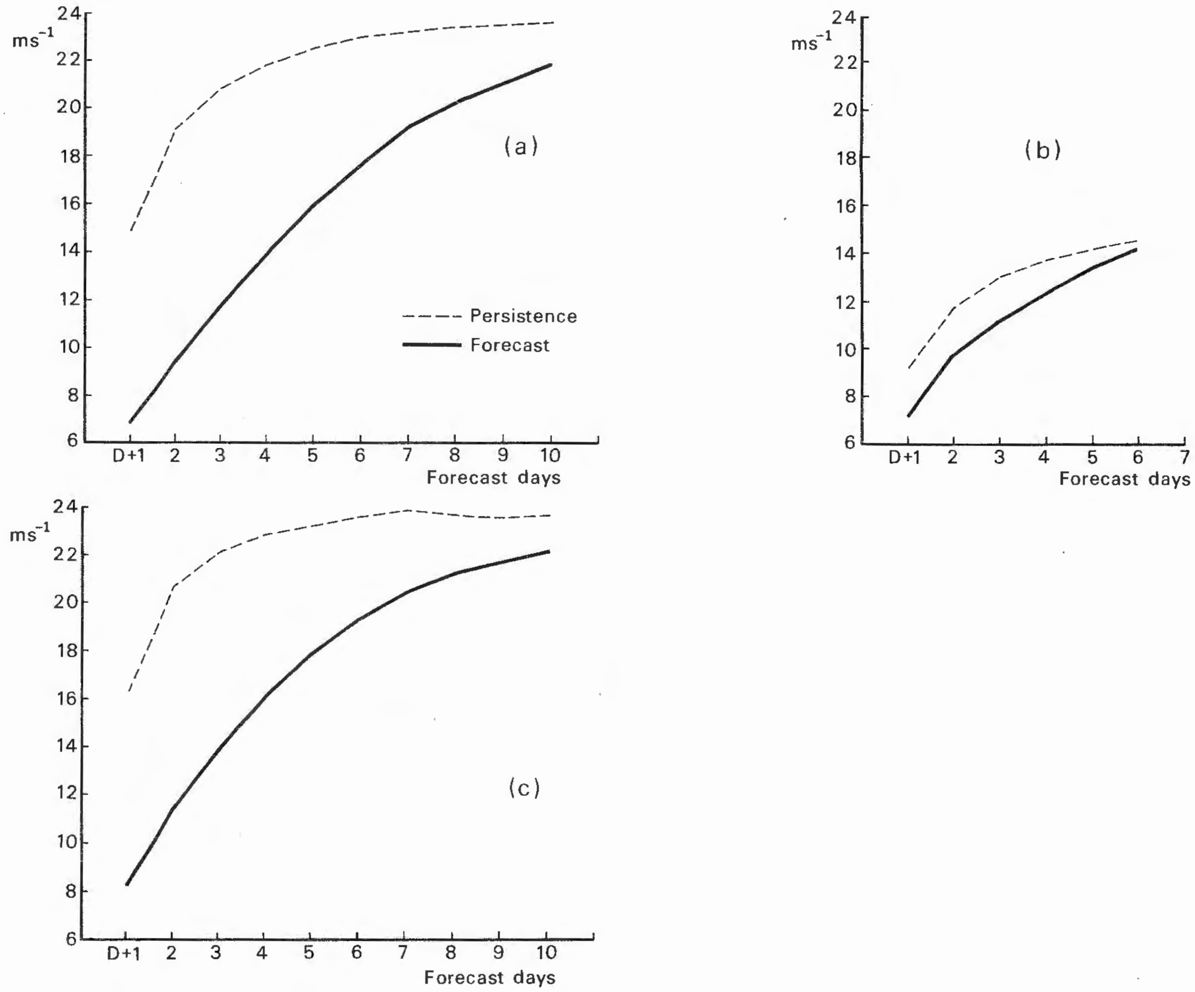


Fig. 6 Root mean square error of the 200 mb vector wind forecast in 1982 compared to persistence in (a) the Northern Hemisphere (b) the tropical belt and (c) the Southern Hemisphere.

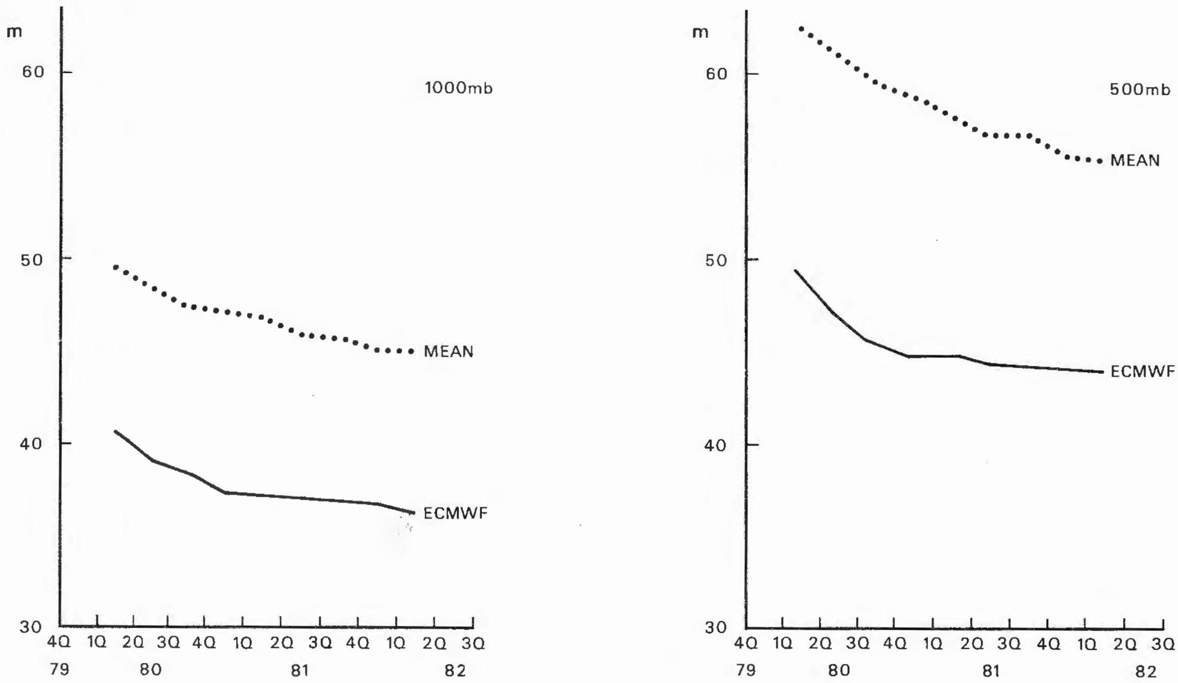


Fig. 7 12 month running mean root mean square of the standard deviation of the forecast error of the three-day height forecasts for the Northern Hemisphere: ECMWF forecasts compared to average score for four other forecast centres, United Kingdom Met. Office, NMC Washington, Météorologie Nationale (France) and Deutscher Wetterdienst.

Interpretation of Numerical Weather Prediction Products

The verification of forecasts of surface weather parameters available directly from the ECMWF model and the extraction of useful information from the model output is an important task of the Centre. A special product development group was set up in 1982 as a joint project between the Operations and the Research Department. A special seminar on "Interpretation of numerical weather prediction products" and workshop on "Statistical interpretation and verification of ECMWF products" were also organised by the group.

In order to facilitate access to the data, a European archive was set up. This is basically a subset of the ECMWF general (global) archive, containing observational data and grid point analysis and forecast data for the European area only. A software package was produced and is outlined in Figure 8. This allows the user to run the complete sequence of data preparation, direct model output verification, development of prognostic equations for local and regional weather prediction and testing the equations on independent data from within the Centre or from the Member States.

Figure 9 shows an example of a local surface temperature forecast in the medium range at Hannover in northern Germany. The forecast is averaged over three and a half days and valid on the period centred on forecast Day 5 (broken line). The observed temperature averaged over the same period are plotted for comparison (full line). Cold and warm spells are reasonably well predicted five days in advance, especially the very high temperatures towards the end of May. Note the positive bias in the forecast, which can easily be allowed for using simple interpretation methods.

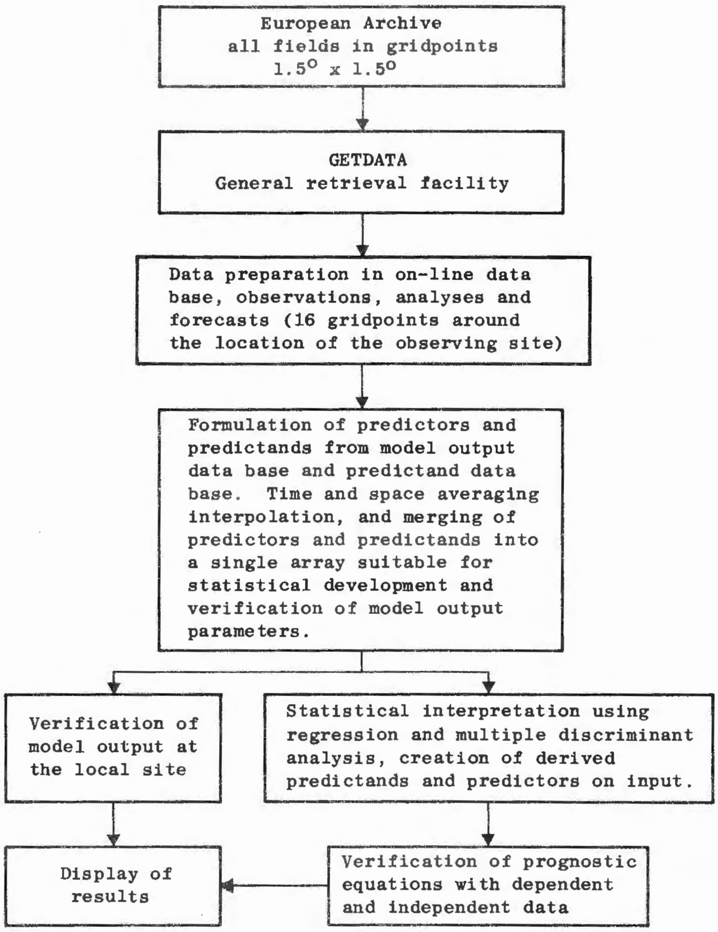


Fig. 8 ECMWF system for local verification and interpretation for the European area.

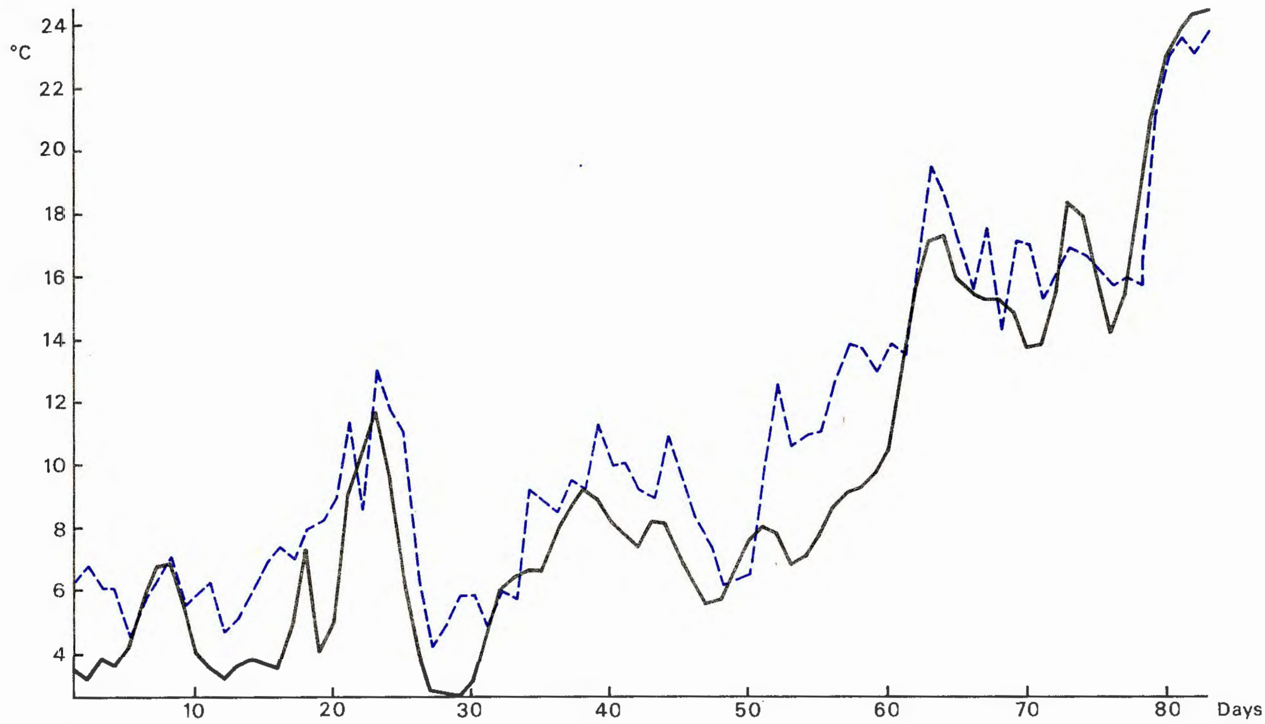


Fig. 9 Medium-range local surface temperature forecast for Hannover averaged over 3½ days and valid for the period 1 March-31 May 1982 centered on forecast day five (broken line) ; observed temperatures averaged over the same period (solid line).

Contacts with Member States

Visits were made to meteorological services of the Member States to present meteorological seminars and to discuss with the staff concerned their experiences with and use of ECMWF products. Such visits were made during 1982 to Belgium, Denmark, Federal Republic of Germany, France, Ireland, Austria, Switzerland, Finland, Sweden, Turkey and the United Kingdom. Visits to the other Member States were made during 1981. Several visits were also made by staff from the computer user support section to Member State installations.

The ECMWF Computer System, Telecommunications Network and Graphics Facilities

Figure 10 shows the configuration of the ECMWF computer system and telecommunications network at December 1982. The Cyber 835 (formerly known as the 730E) was introduced into service in January and passed final acceptance in March. This helped to improve the computer service, and in particular the interactive service, to the users.

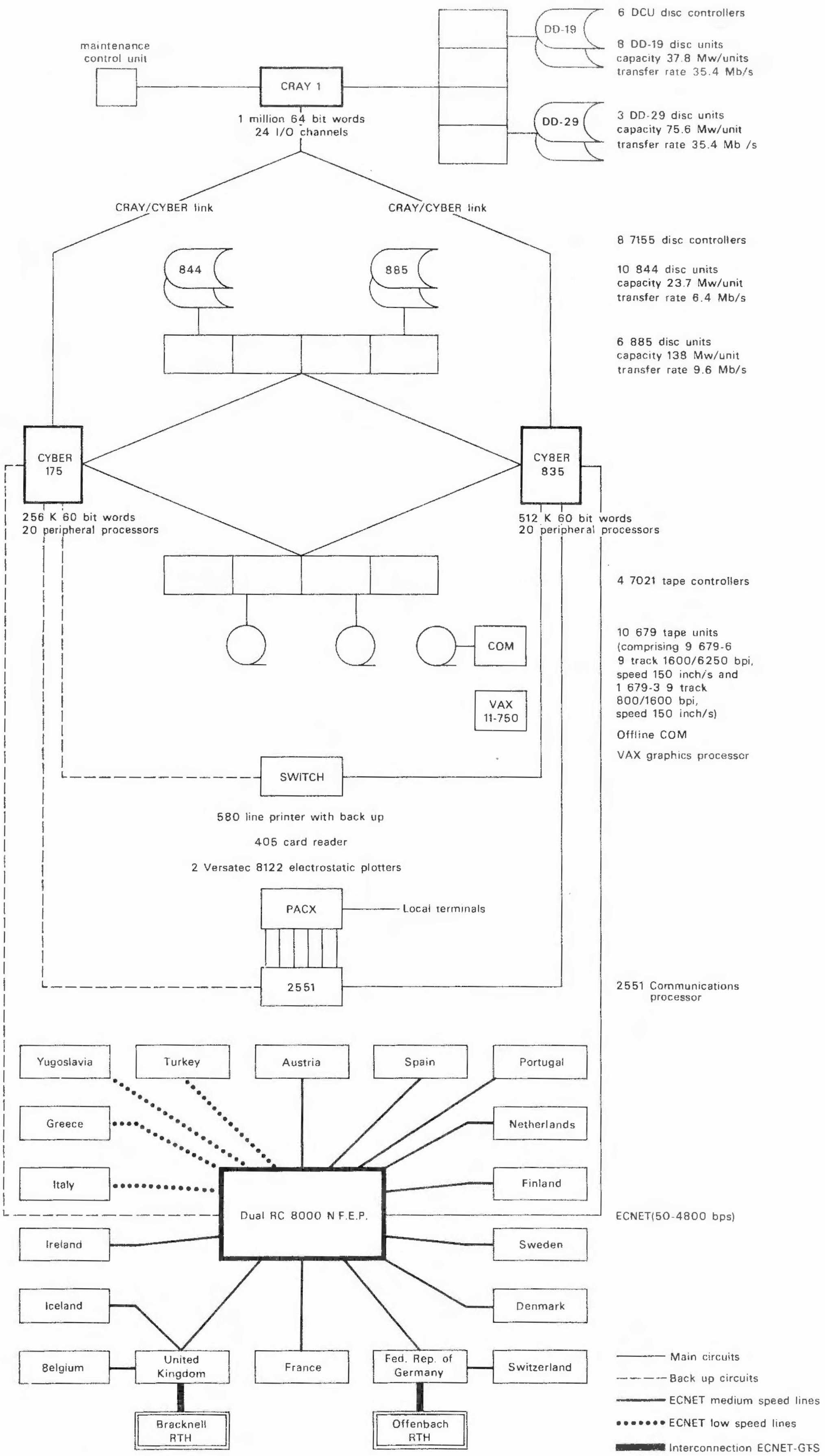


Fig. 10 The configuration of the ECMWF computer system and telecommunications network (ECNET) and interconnections to the Bracknell and Offenbach Regional Telecommunication Hubs (RTH) of the global telecommunications system (GTS) of the World Meteorological Organization.

The high level of reliability of the computing service can be seen from Table 1, which shows the performance of the mainframes in 1982 and previous years. Table 2 shows their usage. The figure given for operational forecast trials for 1982 includes an estimate of the usage by the Centre of the United Kingdom Atomic Energy Authority CRAY-1 computer at the Harwell site (see below).

Table 1 Performance of the CRAY-1 and CYBER system in 1982 and previous years

	CRAY-1			CYBER 175		Dual CYBERS
	1980	1981	1982	1980	1981	1982
Number of jobs run (thousands)	191	199	219	1138	1230	1734
Number of computing units used (million units)	4.2	4.4	4.8	3.9	5.0	6.2
Number of hours of central processing time	4185	4493	4699	3520	3881	4849
Average availability (%)	98.5	98.9	98.9	97.6	99.4	98.8
Mean time between hardware faults (hours)	75.2	78.8	92.3	118.4	119.2	73.2
Mean time between software faults (hours)	111.9	129.5	515.0	100.5	123.7	178.5
Mean time between any faults (hours)	45.2	71.4	78.8	78.0	95.7	51.8

Table 2 Computer usage for 1982 and previous years in 000's of units

	CRAY 1-A			CYBER		
YEAR	1980	1981	1982	1980	1981	1982
Member States	315	484	489	134	136	189
Member States special projects	3	2	4	9	9	11
Operational forecast production	1334	1457	1621	1534	2876	3623
Operational forecast trials	369	236	779*	260	275	156
ALPEX	0	0	22	0	0	263
FGGE	473	291	0	515	318	0
Centre Research and Development	1696	1948	2491	1405	1347	1960
Overall TOTAL	4190	4418	5406*	3857	4961	6203

* including 575K units for operational forecast trials on the Harwell CRAY-1 computer

In addition to the introduction into service of the Cyber 835, the following major developments in the computer and telecommunications services took place in 1982:

- An alphanumeric microfiche system was selected and incorporated into the operational system
- Twentyfour additional ports were added to the inhouse terminal system
- The operating systems on the Cyber and Cray computers were upgraded during the year
- Additional computer time was acquired by means of a contract negotiated with CRAY (UK) on a computer system installed at the Harwell site of the United Kingdom Atomic Energy Authority
- Medium-speed links to the Netherlands, Portugal and Spain entered operation and the low-speed links to these Member States were terminated. A dissemination bottleneck in data transfer between the Cyber and network front-end processor systems was identified and removed
- Telecommunications circuits to Sweden and the United Kingdom were upgraded to V27 bis (4800 bps, automatic equalization)
- A tape management system for the magnetic tape library was implemented
- A statistics data base was designed and implemented; this will allow improved monitoring of the system performance

Extensive studies during the year led to the issue of an Invitation to Tender for a data handling sub-system and a local computer interconnection sub-system. This will allow future changes in the computer hardware and software to be carried out more easily without disruption of the service to the user. It will also result in more efficient data handling and graphical services to the users.

Benchmarking exercises were executed on the CRAY X-MP computer system in June and in October; the computer was found to be fully compatible with the current CRAY-1A. With the CRAY X-MP throughput can be increased by at least a factor of three. Contract negotiations in respect of the CRAY X-MP were begun.

Graphical facilities at the Centre have been improved during the year; the following are among the important developments which have taken place.

- A separate processor for graphical work (a DEC VAX 11-750) was selected and delivered. Future graphical devices will be connected to this processor
- Various plotting packages which are available were evaluated; the DISSPLA/TELL-A-GRAF software package was selected and installed
- The capabilities of the AYDIN colour graphics terminal were improved by the provision of software to display observations on this terminal

Consultants and Visiting Scientists

During 1982, the Operations Department employed the following consultants, visiting scientists and experts:

Mr. A. Ducrot	INRIA, Rocquencourt, France
Dr. S. Grønaas	Norwegian Meteorological Institute, Oslo, Norway
Mr. E. Hellsten	Finnish Meteorological Institute, Helsinki, Finland
Mr. S. Jay	University of Arizona, USA
Dr. G. Lee	CERN, Geneva, Switzerland
Mr. M.R. Lewis	Crowthorne, United Kingdom
Dr. J.W. Münch	Universität Gesamthochschule Siegen, Germany
Mr. D. Niebel	University of Stuttgart, Germany
Dr. R. Saktreger	University of Reading, United Kingdom
Mr. W. Schliffer	University of Würzburg, Germany
Mr. G. Thomson	University of Bath, United Kingdom
Mr. L.J. Wilson	Atmospheric Environment Service, Canada
Dr. A. Wolski	Finnish Meteorological Institute, Helsinki, Finland

Research Department

Research during 1982 was concentrated on identifying the weaknesses in the operational forecasting system, on understanding the sensitivity of the Centre's models to changes in the specification of surface parameters - soil moisture, orography, etc, and the formulation of the physical parameterization.

The ultimate limiting factor on forecast skill is the instability of the atmosphere; small errors in the forecast will amplify rapidly. For small errors the doubling time is about two days; as the errors grow the amplification rates decrease, and drop to zero when the forecast has lost all skill.

During a period of sabbatical leave at the Centre, Professor E. Lorenz from the Massachusetts Institute of Technology, studied the growth-rates of error in the existing analysis/forecast system and compared these growth-rates with estimated growth-rates for a perfect model. The perfect model estimates were derived as follows. In Figure 11 the heavy curve (labelled 1) indicates the observed growth-rate of the root mean square error of the 500 mb height. The curve labelled 2 shows the rate at which forecasts whose initial data were separated by one day diverged from each other. For example, at Day 6 it compares the root mean square differences between the valid six-day and seven-day forecasts for all verifying days. It thus estimates how fast error in a perfect model would grow, given that the errors in the initial data were the same as typical one-day forecast errors. A simple analysis shows that the observed error growth-rates are always larger than perfect model values and are 50% larger than the theoretical growth-rates for small errors. There is thus considerable scope for improvement in the forecasts.

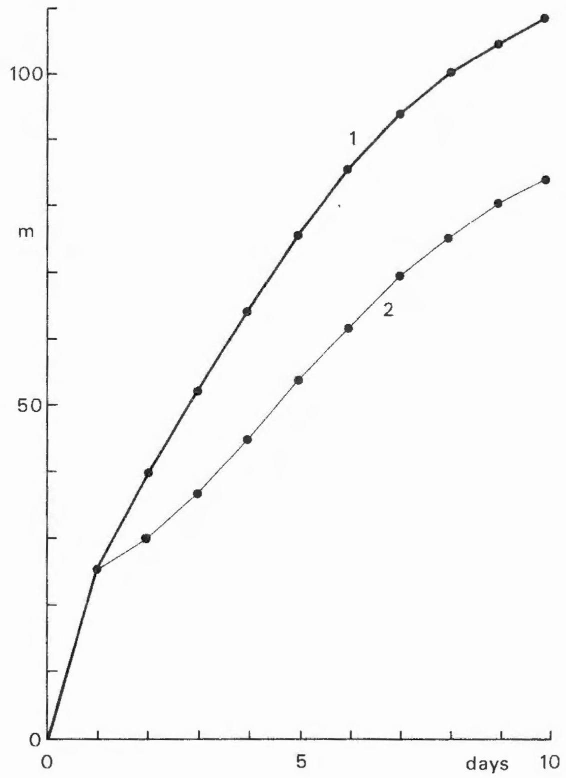


Fig. 11 The global root mean square error of 500 mb height in metres (heavy curve, labelled 1) for all operational forecasts from 1 December 1980 to 10 March 1981, and the corresponding root mean square difference (light curve, labelled 2) between forecasts for a particular time starting from data one day apart.

Based on these considerations, Lorenz estimated that, with no change in the one-day forecast errors, model improvements alone could, in principle, lead to the current skill at Day 7 being extended to Day 9 or even Day 11; that is a two to four day improvement. Essentially, this suggests that model improvements alone would result in the heavy curve in Figure 11 being moved much closer to the theoretically optimum curve labelled 2.

Moreover, all these results are sensitive to the magnitude of the one-day forecast errors. If these could be halved (either through data, analysis, or model improvements) then a further two days could be added to the range of useful predictability.

In summary, Lorenz's work suggests that the level of skill currently attained at one week range can in principle be extended to one and one half and perhaps two weeks.

Data Assimilation

Numerous improvements were made during the year to the operational data assimilation scheme. The success of a complete data assimilation cycle is dependent on many component parts within that cycle and several of these components have been affected by improvements.

A necessary requirement for a good assimilation is a rigorous pre-analysis of the data, exploiting as many quality control and diagnostic checks as possible. Considerable progress in this area has been made during the year as a result of a joint project with the Operations Department. Various sources of data received via the GTS were seen to have a systematically detrimental influence on the analysis. Examples are observing platforms with persistently incorrect reports; platforms with random and systematic errors sufficiently large to render them useless; and surface observing platforms which fail to conform to regional practices in their reporting of pressure data. Many of these sources of error are now excluded from the analysis.

Within the analysis itself a common problem is how to make an optimum selection of data. Universally applicable selection algorithms are difficult to design, because of enormous variation in the density of observations over the globe. The technique applied in the analysis scheme of the Centre seeks to resolve the problem by making a comprehensive selection of data and using it not just for a single grid point, but for a set of grid points within a box of 600 km x 600 km. Case studies undertaken during the year however revealed deficiencies within the data selection algorithm, despite these measures. The deficiencies arise in data rich regions, most notably in Europe, where data thinning is found to be necessary. This is now done by combining closely adjacent reports into a single representative observation, and by careful ordering of the basic data to ensure a representative sampling.

Probably the most serious weakness of the current data assimilation scheme is its failure to capture fully the intensity of rapidly developing depressions. This problem, of course, is not unique to the Centre's scheme. A much better understanding of the problem has been obtained during the year. The basic structure function used in the analysis, to analyse increments to be applied to the first guess field, is a Gaussian with "half-width" b (currently = 600 km). This function, which is similar to that used in many other analysis schemes, yields reasonable results in many circumstances but fails to resolve smaller scale features absent in the first guess, a problem that is not eliminated even if there is a high density of observational data. Idealised studies investigating the interplay between scale of first guess error, the density (and accuracy) of the observing network, the analytic form of the structure function and finally the imposed constraints of mass and wind balancing have very much helped an understanding of these problems. Work in the area is continuing and statistics are now being accumulated operationally for a re-evaluation of the structure functions.

Versions of the data assimilation have been developed which permit higher resolutions than are currently used operationally both in the vertical (15 → 19 levels) and temporally (6 hourly → 3 hourly cycle). Both techniques indicate potential improvements over the current scheme.

A new version of the initialization was introduced operationally during the year. Formerly the initialization was adiabatic. The major shortcoming of adiabatic nonlinear normal mode initialization is the suppression of diabatically driven circulations, the most prominent example being the tropical Hadley circulation. Inclusion of the necessary physical processes had not been possible because of the convergence problems involved in the iterative process. Using an estimate of the diabatic forcing which does not interact with the iteration helps to circumvent the problem. This estimate is computed by time-averaging the physical tendencies (convection, radiation, vertical diffusion) during a two-hour forecast starting from the uninitialized analysis. An additional "gravity-mode" filter, which keeps only those components which force inertia-gravity waves with periods longer than a certain cut-off period, retains the large scale, climatological features and discards the less reliable small scale structures. The impact of such a diabatic initialization was evaluated by re-running a 6-day assimilation sequence, 5-11 June 1979. Figure 12 shows the time-averaged (6 days), initialized velocity potential at 200 mb for adiabatic initialization. Figure 13 shows that diabatic initialization leads to stronger divergent circulations. Other improvements include the retention of the Hadley cell and a reduction of the 'spin-up' time of the model. Verification scores show an improvement in the tropics for the first two days of the forecast, particularly for the long waves. After 5 days, a modest improvement shows up in the extratropics.

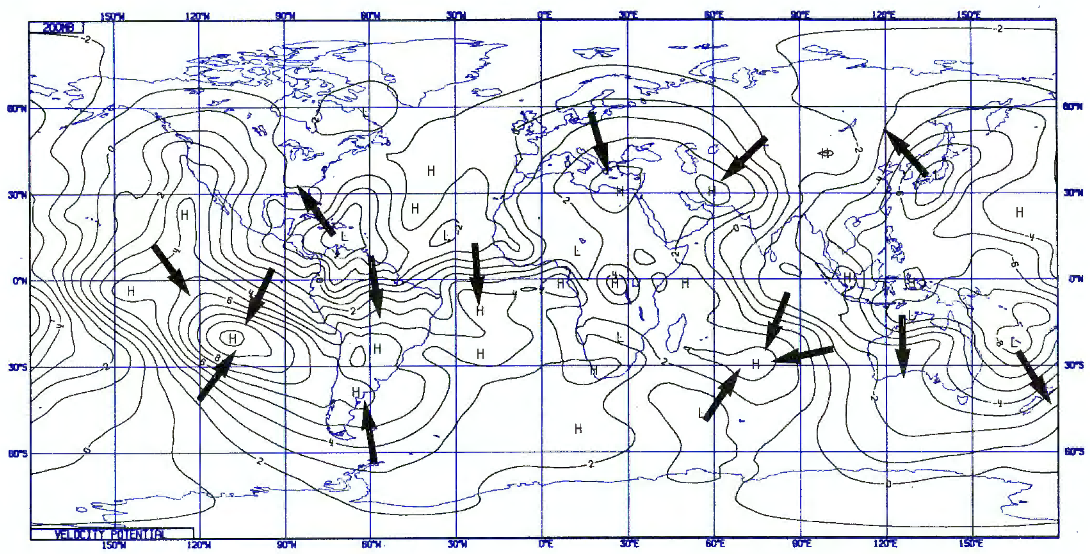


Fig. 12 *Time averaged (6/6 to 11/6 1979), initialised velocity potential at 200 mb, old initialisation scheme; units : 10^6 m^2/sec. The associated divergent wind field is up-gradient, and is directed from low values of the velocity potential to high values.*

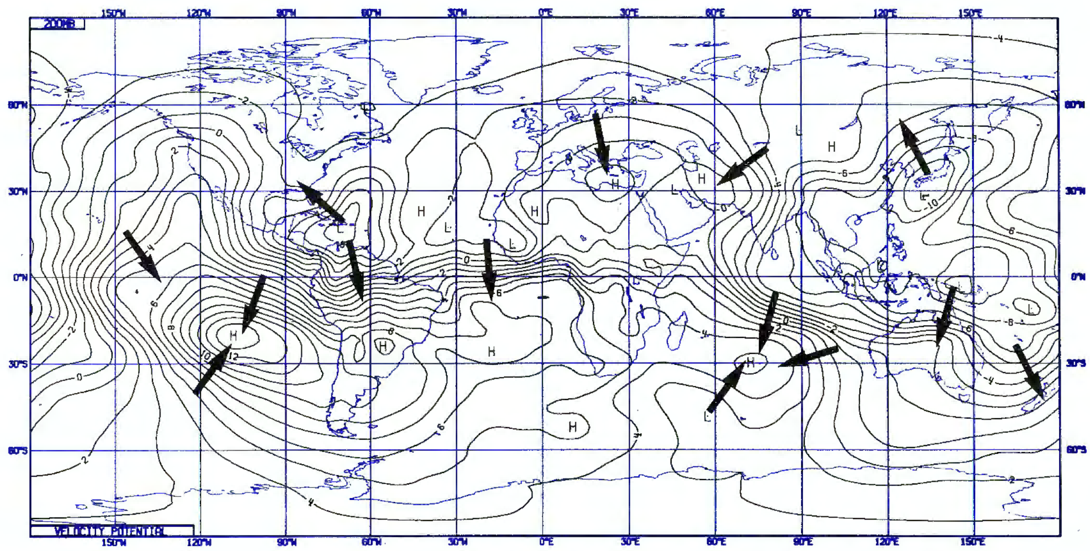


Fig. 13 *As for Fig.12 but for the new initialisation scheme.*

An analysis of sea surface temperature is now included in the operational suite. This is based on the (5° x 5°) National Meteorological Center (NMC) analysis issued daily over the Global Telecommunications System; spatial interpolations being necessary to convert this data to the model grid (1.875° x 1.875°). Benefits of the use of such analyses, rather than monthly climatologies which were in use previously, are evident during periods of rapid seasonal transition and also during cases of marked anomaly such as those apparent over the tropical East Pacific at the end of 1982.

The New Forecasting System

A major project within the Research Department during 1982 has been the design, development and testing of a new forecasting system which will be introduced operationally early in 1983. The major difference between this system and the Centre's first operational system lies in the formulation of the adiabatic part of the forecast model which, following extensive trials reported in earlier annual reports, is based on use of a spectral horizontal representation of upper air fields. In addition, a more flexible vertical representation has been adopted, enabling the model to be run using either the conventional, terrain-following, "sigma" coordinate, or a hybrid coordinate for which there is a smooth transition from a terrain-following system near the earth's surface to a pressure coordinate in the lower stratosphere. A modified, more efficient time-stepping method has also been used, and in an extreme situation a timestep more than twice that used operationally has proved possible. An objective verification for this case is shown in Figure 14.

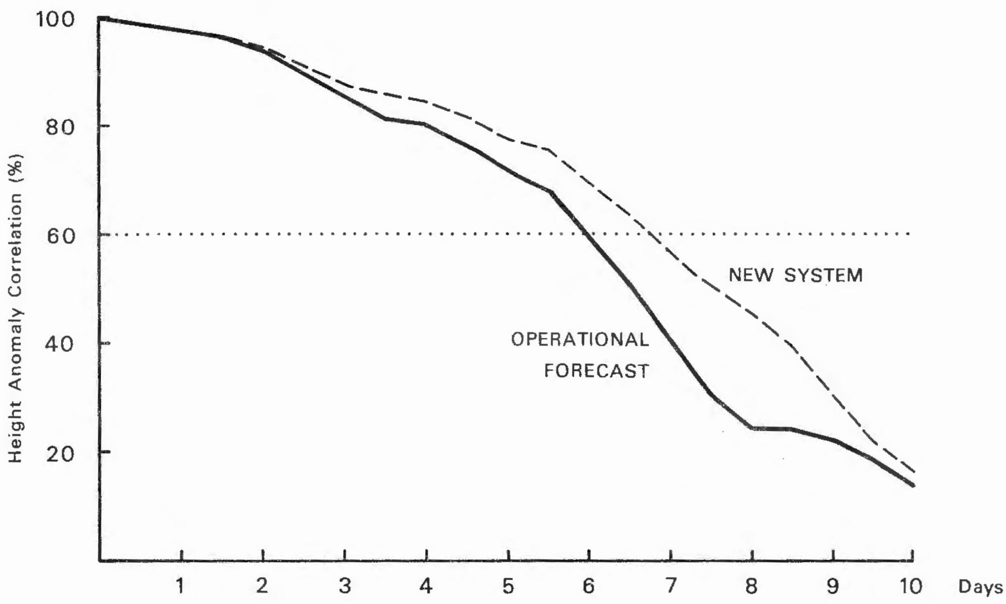


Fig. 14 *Anomaly correlations of geopotential height for the region between 20^{o} and $82.5^{o}N$ and for standard pressure levels between 1000 and 200 mb. The solid curve denotes the operational forecast from 4 Oct. 1982 which was performed with a 10-minute time-step. The dashed curve denotes a forecast made with the new forecast model using a 22½ minute time-step.*

Although the basic types of parameterization scheme will be unchanged in the first operational version of the new system, the existing sub-routines have been reprogrammed to adopt the new vertical coordinate and a new computer programming standard. The opportunity has been taken to introduce a number of revisions to the parameterizations. Among these are a distinction between the latent heats of vaporization and sublimation, and a generally more consistent treatment of moist processes, including use of separate specific heats for dry air and water vapour.

Other benefits of the new system include a flexible program organization to allow higher resolution experimentation to be carried out without further recoding, and use of memory management routines and documentation standards aimed at facilitating experimentation with new formulations both within the Centre and by Member States.

Extensive testing of the new model began during the last quarter of 1982. A revised post-processing system which enables the full range of forecast products to be made available to the Member States with no change of format has been completed, and work on the implementation of a normal-mode initialization and on the interface with the Centre's data analysis scheme has also been carried out in preparation for the final testing of the complete new system prior to its operational implementation.

Orography

Numerous experiments and diagnostic studies have shown that a significant proportion of the model's systematic error can be attributed to an under-estimation of the orographic forcing in the model. Considerable efforts have been made over the last year to find a suitable representation for the model's "mountains". An "envelope"-type orography - an orography that is nearer to the grid-square maximum terrain height rather than to the grid-square mean in regions of very rugged terrain (see Figure 15) has been found to improve the forecasts substantially; predictability was improved by several hours and the Day 7 systematic errors in the 500 mb height field were almost halved (see Figure 16).

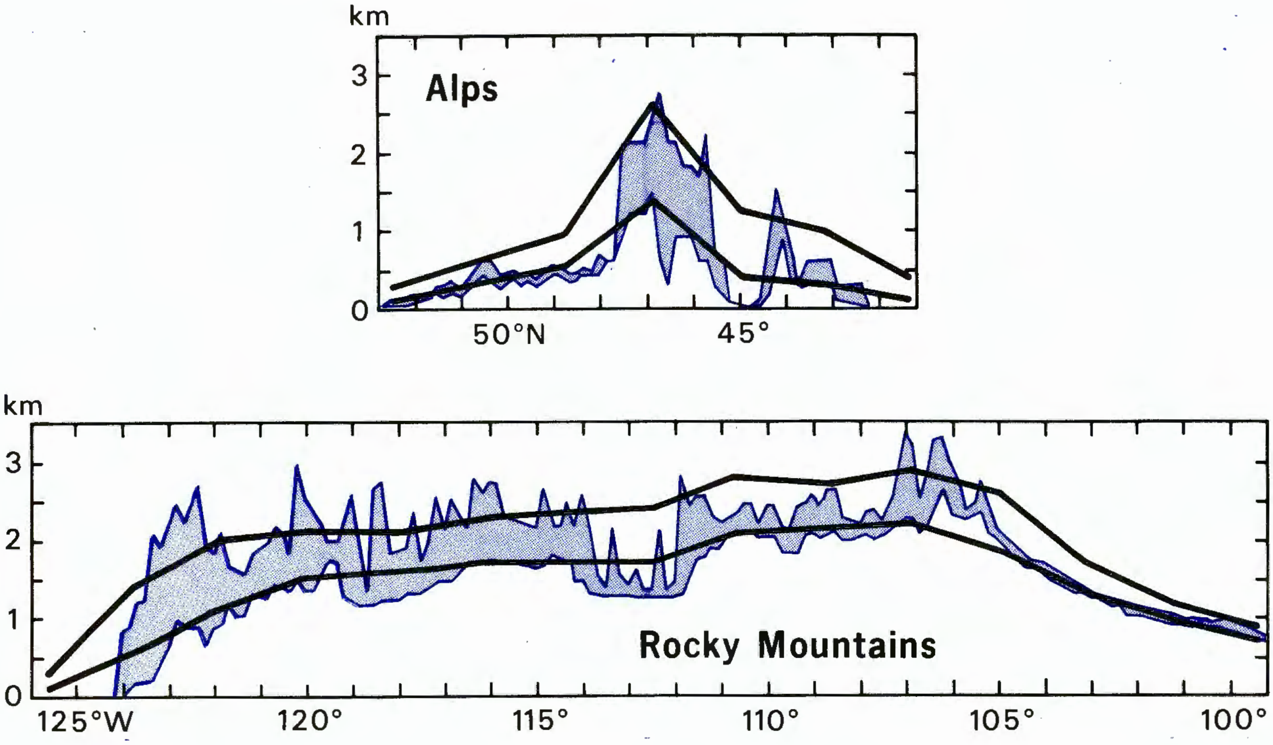


Fig. 15 *Vertical cross-sections through the Alpine and the Rocky Mountain ranges illustrating the height of the envelope orography (upper solid line) and the operational orography (lower solid line); shading indicates the range of terrain heights between grid-square maximum and minimum values.*

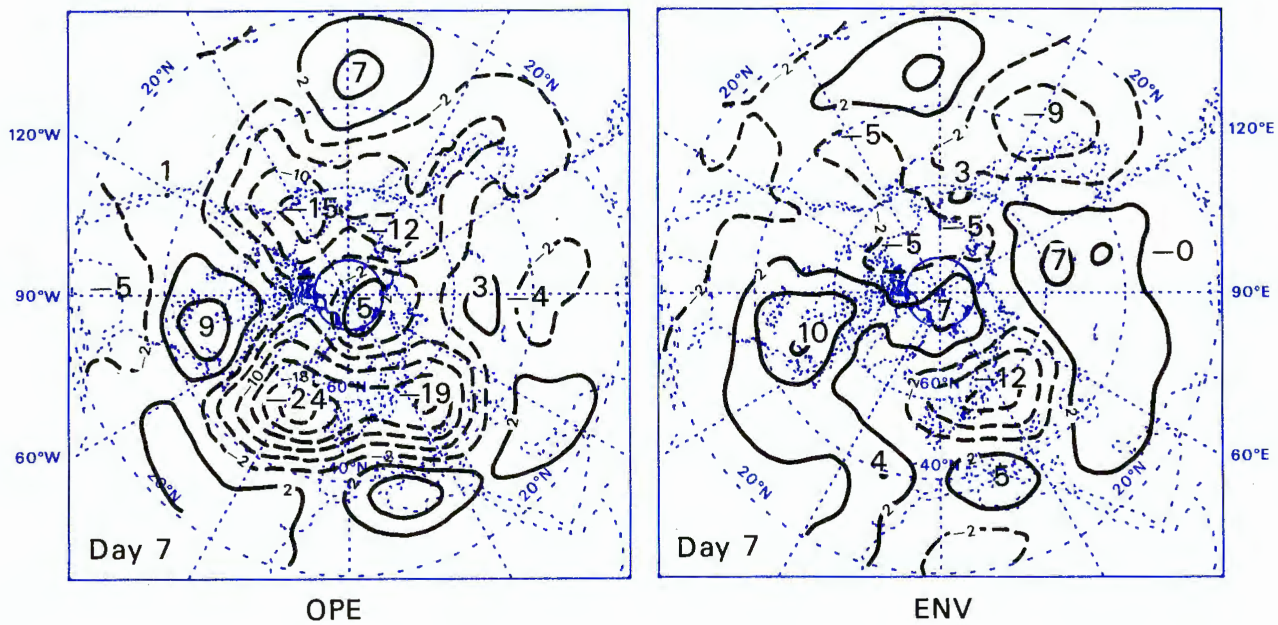


Fig. 16 *Mean 500 mb geopotential height error for the day 7 forecasts (January 1981); left panel (OPE) operational forecasts, right panel (ENV) "envelope" orography forecasts.*

Numerical Techniques

Two new investigations of the numerical treatment of variables in the vertical were started in 1982. A fourth-order finite-element scheme has been shown to give very accurate results for the one-dimensional advection equation, and a formulation has been derived for an irregular vertical resolution. Its implementation on a trial basis within the framework of the new forecasting system has begun. In addition to this work, alternative "flux-corrected" techniques for describing the advection of rapidly-varying quantities are being examined. Such techniques are expected to be principally applied to the treatment of moisture variables.

Dynamical Studies

Some work of a more fundamental theoretical nature has continued, the aim being to understand better the vertical structure of both the slowly-varying anomalies of the atmospheric circulation and the mean error fields of the Centre's extratropical forecasts. These theoretical studies and the results of experiments with simple models suggest that some atmospheric patterns are inter connected over large distances. These so-called 'teleconnections' are caused by many triggering mechanisms such as tropical (diabatic) heating, orographic extratropical forcing or forcing by shorter-period transient eddies. The experimental results are in good agreement with the observational picture obtained for low-frequency disturbances as a result of a joint University of Reading/UK Meteorological Office diagnostics project based on the Centre's operational analyses. This work has also been used as part of the orography project, reported above, to help understand the relationship between erroneous orographic forcing and systematic errors in the forecast.

Diagnostic Studies

In trying to understand atmospheric motions it is often helpful to break down the fields into zonal Fourier modes. The technique may be applied to long time series of analysis or forecast data. In the case of forecast data, the time series could be the daily forecasts of an extended integration of several months, or a series of, say, one-day forecasts.

A comparison of frequency-wavenumber analyses of series of one-day forecasts, two-day forecasts, etc, reveals a systematic change in the amplitude and phase structure of the transient waves during the forecast. For example, a common feature during the two winters 1980/81 and 1981/82 is a reduction of amplitude in the upper troposphere of eastward travelling baroclinic waves and a slight increase in amplitude at the surface, as shown in Figure 17a for zonal wavenumber 7 with a period of 3-5 days. Figure 17b shows the corresponding vertical phases; note the increased forward tilt of the temperature wave in the forecasts, suggesting that the model tends to develop a slightly too baroclinic atmosphere.

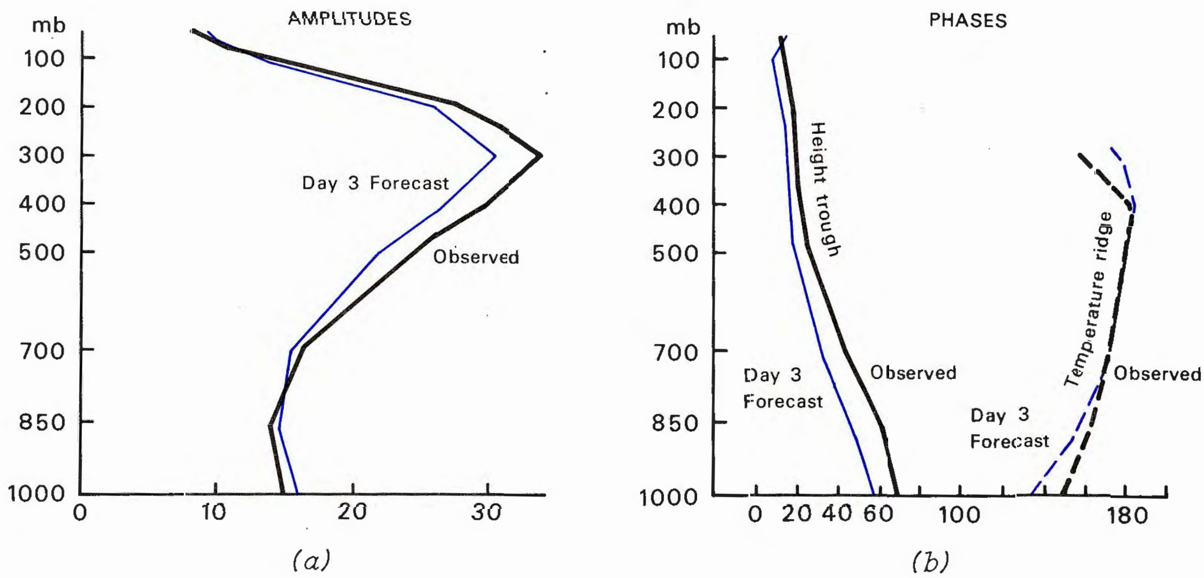


Fig. 17 : Vertical profiles for the geopotential height - zonal wavenumber 7 (travelling eastward), period 5.3 days; mean over the latitude band 43° to 64°N; left panel (17a) amplitude (metres), right panel (17b) phase.

Various diagnostic studies have shown that the overprediction of precipitation over Central Europe and the underprediction over the Mediterranean are related to incorrect steering of cyclones by the forecast upper tropospheric flow, which has a tendency to become too zonal, often failing to produce the diffluent flow over Europe. Comparing the individual growth rates of particular features of the systematic error early in the forecasts might reveal the primary source of error. Rapid error growth occurs in the tropics and in relation to high mountains.

Monthly means of Day 1 forecasts show typical tropical wind errors of up to 8 ms^{-1} at 850 mb and 12 ms^{-1} at 150 mb. The errors continue to grow during the forecast but at a much slower rate. Such large errors in the quasi-stationary flow suggest problems associated with stationary forcing, i.e. orography or large scale heating. The large scale Day 1 errors in the tropical flow field have a surprisingly simple structure, clearest over Africa. At 850 mb the error field has westerlies off West Africa, easterlies off East Africa and cyclonic flow over North and South Africa. A reversed error flow pattern is to be found at 150 mb.

Such flow is suggestive of a heat induced tropical circulation where the heat source is positioned over the equator. This, and simple theoretical studies suggest that a substantial part of the forecast errors in the tropics is associated with erroneous large scale heating at the start of the forecast.

Energetics, variances, covariances and spectra of a selection of parameters continue to be calculated operationally from analysis and forecast data. These provide well established, sensitive, indicators of problems in the analysis-forecasting system.

Parameterization - Convection

Collaboration with Drs. Miller and Moncrieff (Imperial College, London) continued. The description of convection, and indeed of all turbulent motions, involves an ever-increasing complexity; to make the parameterization of convection manageable, an assumption is made which is physically acceptable and which provides a way of limiting the mathematical equations involved; this is known as closure, or a closure assumption. The "closure" assumption for their scheme no longer depends on large-scale moisture convergence (a Kuo-type closure), but instead on the convective available potential energy (an adjustment closure). This scheme has been tuned and tested using the GARP Atlantic Tropical Experiment (GATE) composite wave data, and its performance is comparable with that of the Arakawa-Schubert scheme.

In global integrations, the most striking difference between the Miller-Moncrieff scheme and the Kuo-scheme (the operational scheme) was the large amount of convective precipitation during the first time-steps of the forecasts. Closer analysis showed that the large precipitation rate is a response to the initial atmospheric stratification which has unrealistically large values of the convective available potential energy. A similar response was found from the Arakawa-Schubert scheme. As a result, a rapid "spin-up" of the Hadley circulation to more than twice the strength observed occurs in the early stages of the forecasts; relaxation of this circulation then takes place and it is not obvious to what extent this influences the medium range forecasts.

During the last quarter of the year, work on the parameterization of shallow convection was started. Both the operational forecasts and extended integrations show a weakening and a north-east displacement of the Azores high. It has been argued that this error is related to the lack of an inter-tropical convergence zone over the Atlantic due to an insufficient moisture supply in the trade wind areas associated with shallow convection. A simple scheme for shallow convection was therefore developed, where sensible heat, moisture and momentum are exchanged vertically depending on the thermal stratification of equivalent potential temperature. In 50-day integrations with the global model the presence of the shallow convection scheme proved to be beneficial, with the moisture supply from the subtropical oceans being increased considerably (globally by 10%), as were the precipitation and the divergent mean flow. The effect on the extratropical flow was most pronounced in the Atlantic high, being both more intense and better placed (see Figure 18). In addition, the integration including shallow convection results in a better position for the Icelandic low and a more accurate simulation of the flow over western Europe and North America.

Parameterization - Radiation

A thorough study of the Centre's radiation scheme was undertaken during 1982. Several problems have been identified.

(i) E-type effect

The broad continuum absorption of radiation in the atmospheric window is probably caused by the water dimer molecule $(H_2O)_2$ whose concentration shows an increase with vapour pressure (e) and a decrease with temperature. This e-type effect has been neglected in the present scheme giving rise to insufficient radiative cooling in the tropical lower troposphere. Inclusion of the e-type effect, with a proper dependence on vapour pressure, has not been possible due to the way the infrared radiation scheme has been formulated (see (iii)). However, some improvement in the cooling has been obtained by adjusting the coefficients of the continuum term in the transmission function.

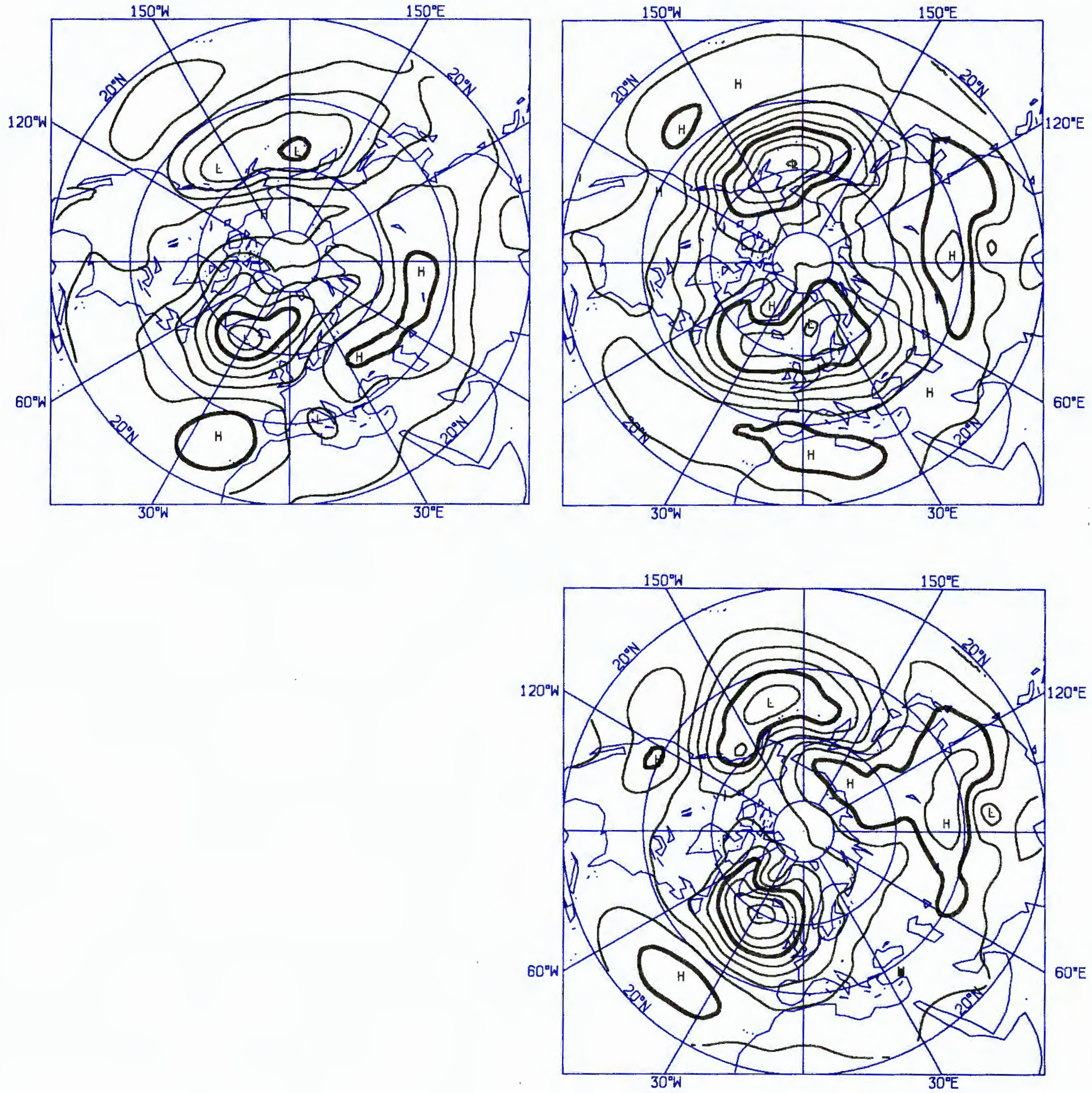


Fig. 18 30-day means of 1000 mb geopotential height; contour interval 4dam; upper left panel analysis - "February" 1979, upper right panel simulation with standard operational model, lower right panel simulation with a specific parameterisation for shallow convection.

(ii) Gaseous transmission function

The equation used to represent gaseous transmission was found to be over-simplified. A revised equation gave significant improvements in the long and short wave radiation fluxes and will be implemented in the new forecasting system.

(iii) Longwave radiation in a cloudy atmosphere

The radiation scheme showed an unrealistically rapid rise in cooling in a cloud layer for small cloud amounts. This is due to the difficulty of treating gaseous effects with the effective absorber pathlength method in an atmosphere with internal radiation sources. To overcome this problem a radiation scheme with a revised treatment of gaseous absorption has been developed. This uses the technique of representing transmissions by exponential sum fitting. Each exponent is equivalent to a monochromatic optical depth which can be easily incorporated into the multiple scattering form of the existing radiation scheme. This method gives realistic cooling rates for cloudy atmospheres and also allows correct treatment of the e-type effect (see (i)).

Parameterization - Cloud-Radiation Interaction

The study of cloud-radiation interaction is a continuing part of the cumulus parameterization project. Whereas the specification of cloud cover for stratiform clouds associated with large scale rising motion appears to be realistic in the Centre's model, the specification of convective clouds in the radiation calculations does not. A series of sensitivity experiments has revealed that the geographical distribution of convective heating, and therefore of the divergent flow in the tropics, is sensitive to the specification of the cloud cover in the radiation calculation. Over land an underestimate of cloud cover leads to excessive surface radiative heating and increased convective activity. Over the oceans an increase in cloud cover enhances convection, presumably due to the greater destabilization resulting from increased radiative cooling in the cloudy regions. These experiments also showed that the mean extra-tropical flow is very sensitive to the positioning of heat sources in the tropics. More experimentation in this area is planned for 1983.

Parameterization - Land-Surface Processes

During 1982 the parameterization of soil processes was revised and a new scheme was introduced into the operational model on 1 December together with new values for the surface albedo. In the new formulation, the soil is represented by three layers of different heat capacities and responds to the thermal forcing on both synoptic and seasonal time-scale; the lowest layer having prescribed monthly mean temperatures and moisture. The new albedo values, obtained from satellite measurements, are more realistic than the old values, the changes being greatest over the dry continental areas and deserts, where the old values were much too small.

Parameterization - Planetary Boundary Layer

As an alternative to the operational scheme for vertical exchanges (diffusion) in the planetary boundary layer, a higher order closure scheme has been developed and tested. One of a hierarchy of closure schemes classified by Mellor and Yamada was selected; this scheme requiring a prognostic equation for turbulent kinetic energy that takes into account its dissipation and production of turbulent kinetic energy by wind shear and buoyancy; vertical diffusion coefficients for momentum, heat and moisture are calculated as functions of the turbulent kinetic energy.

The scheme has been tested and evaluated extensively using the single column version of the model. Preliminary results show that the scheme is capable of reproducing the daily variation of turbulence due to convection in the

Planetary Boundary Layer and gives exchange coefficients comparable to those obtained in other studies.

FGGE Research

The First GARP Global Experiment (FGGE) data, both observations and analyses, have been used extensively in evaluations of new versions of the data assimilation scheme and forecast model. Many of these experiments have comprised a re-analysis of a selected period during the FGGE-year (1 December 1978 - 30 November 1979) and a number of ten-day forecasts from these new analyses.

Considerable attention has been paid to Observing System Experiments (OSE), where the impact of an observing system has been measured both by the quality of the resulting analyses and the improvement in medium-range forecasts using these analyses as initial data.

One such experiment was to study the impact of cloud drift winds for the period 6-18 February 1979. When cloud drift winds were used, a more intense mean Hadley circulation was obtained in the analyses, which improved the quality of tropical forecasts for Days 1 to 3. The impact on the Northern Hemisphere forecasts was positive in three out of four cases, one of which improved significantly.

A more extensive set of OSEs was carried out for the period 8-18 November 1979, a period when two polar orbiting satellites were operating. In all, seven observing system permutations were evaluated. From the resulting analyses, seven 10-day forecasts were run for each permutation. To highlight how large an impact can be made on the medium-range forecasts, two similar 'extreme' experiments, one with all data and one excluding satellite temperature soundings (SATEM), satellite cloud drift winds (SATOB) and aircraft data (AIREP, AIDS, ASDAR) were carried out. Anomaly correlations of height were calculated for each forecast and the mean of the seven anomaly correlations in the Northern Hemisphere is shown in Figure 19. The contribution from the satellite and aircraft data extends over all time scales during the forecasts and predictability at the 60% level is seven days for the experiment using all FGGE data compared with five and a half days for the experiment where satellite and aircraft data were excluded. The experiment as a whole indicated that all the FGGE observing systems can contribute towards better forecasts. However, the importance of each system per se, depends strongly on the synoptic situation and the geographic distribution of the observations.

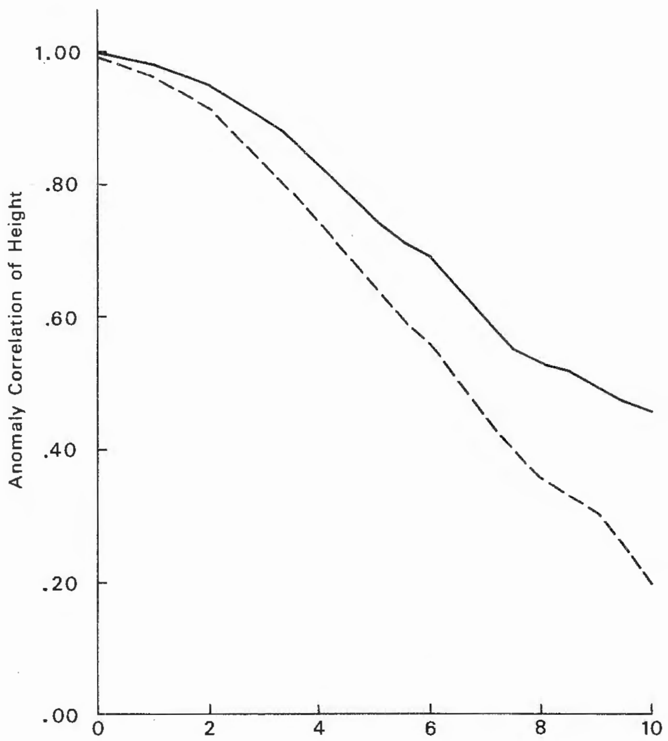


Fig. 19 Mean North Hemispheric (20^o to 82.5^oN) scores - anomaly correlation of geopotential height - for 7 forecasts; solid line - full FGGE observing system, dashed line - satellite and aircraft data excluded.

Consultants and Visiting Scientists

During 1982 the Research Department employed the following consultants, visiting scientists, or experts:

Dr. A. Baede	Koninklijk Nederlands Meteorologisch Instituut, De Bilt, The Netherlands
Dr. W. Bourke	Australian Numerical Meteorological Research Centre, Melbourne, Victoria Australia
Dr. Chen-Shou-Jun	Dept. of Geophysics, Peking University, Beijing, China
Dr. R. Daley	National Centre for Atmospheric Research, Boulder, Colorado, USA
Dr. C. Dey	National Meteorological Center, Washington DC, USA
Dr. Ji, Li-ren	Institute of Atmospheric Physics, Peking, China
Dr. M. Miller	Imperial College of Science and Technology, London, United Kingdom
Dr. M. Moncrieff	Imperial College of Science and Technology, London, United Kingdom
Professor D. Radinovic	Faculty of Mathematics and Natural Sciences, Dept. of Meteorology, University of Belgrade, Yugoslavia
Dr. J.M. Wallace	University of Washington, Seattle, Washington, USA

Administration Department

Following the decision taken by the Council at its 11th session held on 10-11 April 1980, the Administration Department in 1982 operated for the first full year under the new organizational structure consisting of two sections.

Externally, the Administration Department continued the Centre's liaison with the Co-ordinated Organisations and the European School. The Administration Department also finalised an agreement between ECMWF and the German Building Society for Civil Servants (BHW) to enable staff members to obtain house mortgages. Negotiations have been started with the U.K. Treasury for possible transfer of pension rights for British staff members.

Financial Management

A review of the past seven years' budgetary estimates shows that these, and in turn associated annual surpluses, have been controlled in an increasingly strict manner. Figure 20 shows the decrease in the budgetary surplus over the years 1976-1982.

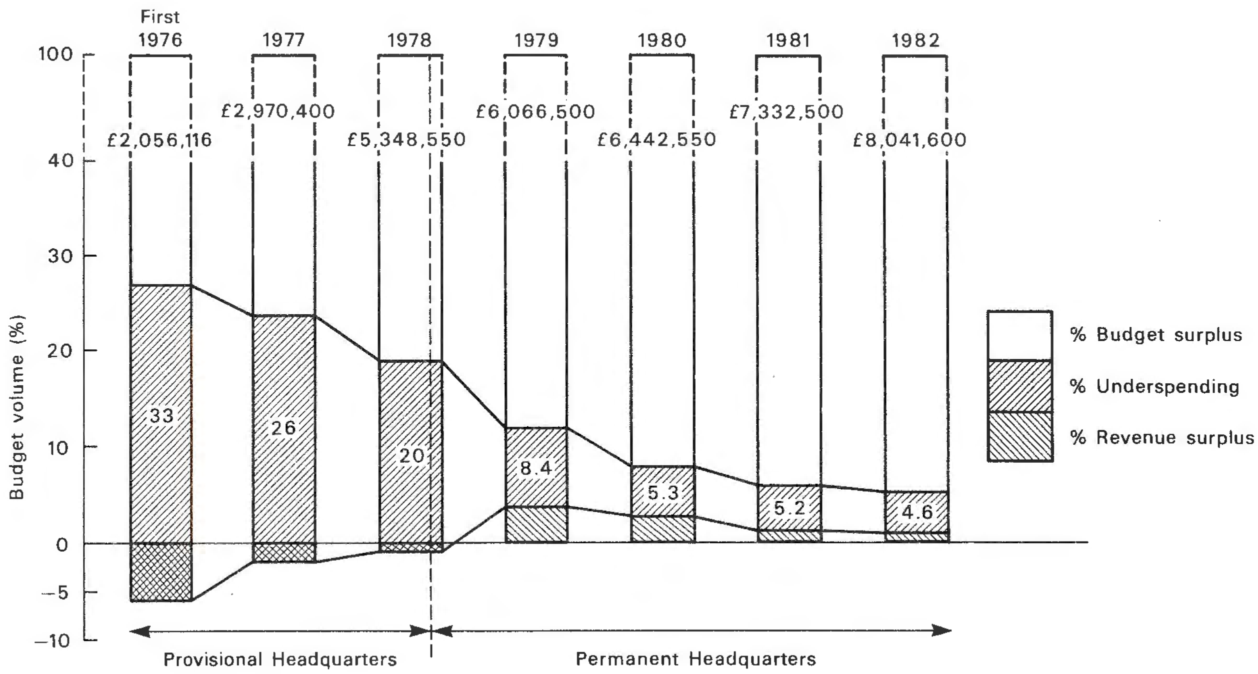
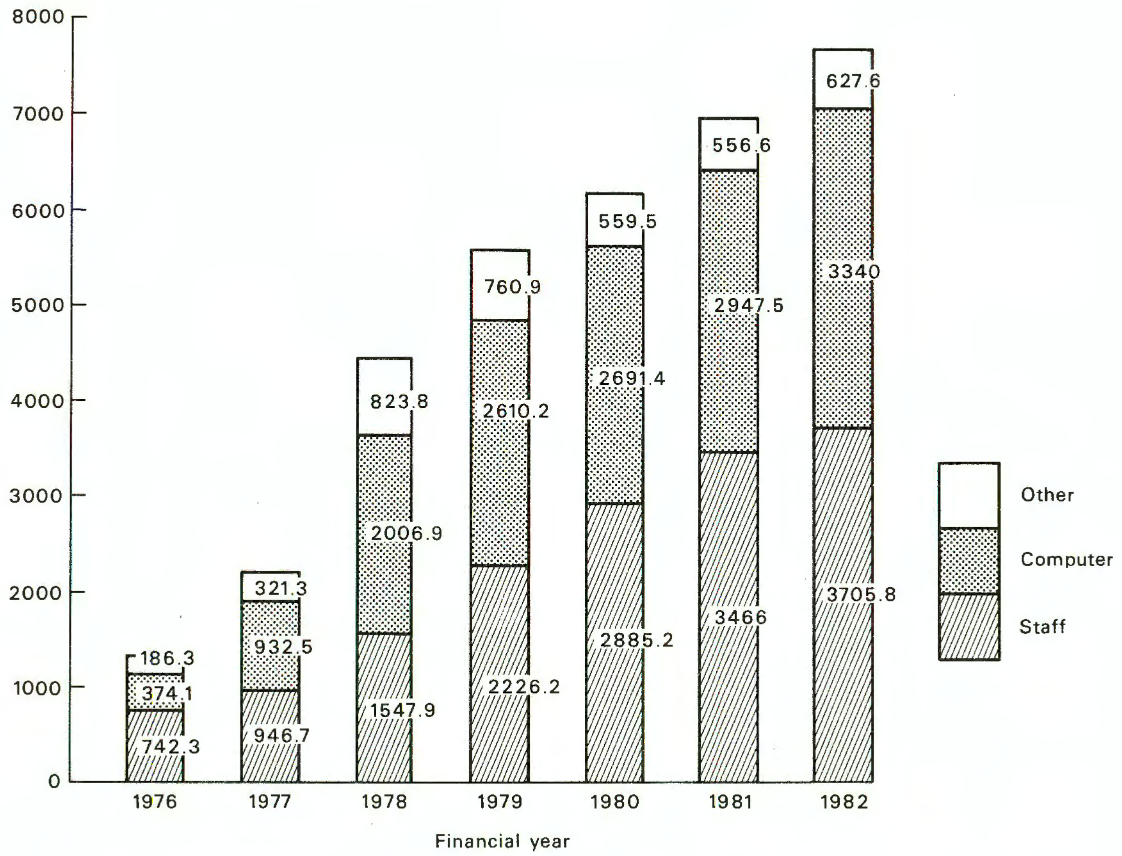


Fig. 20 Percentage budgetary surplus and underspending for the first seven financial years 1976-1982.

Budget

The Centre's Budget 1982 was adopted by the Council at its 14th session held on 19-20 November 1981. The approved total revenue and expenditure for the year 1982 was £8,041,600 - an increase of £709,100 (+9.67%) over the Budget 1981. The increase was due to salary adjustments and higher operating expenditure. The total expenditure was mainly covered by the financial contributions of the Member States, supplemented by the proceeds of taxation, staff contributions to the Pension Scheme, bank interest, and other miscellaneous revenue such as tax refunds, etc. Figure 21 shows the total expenditure in the years 1976-1982 for staff, computer costs, and other expenditure.



Note: Figures revised for 1979-80 to include certain 'computer' expenditure previously included in 'other'

Fig. 21 Expenditure on staff, computer operations and other items during 1976-1982.

Scale of Contributions

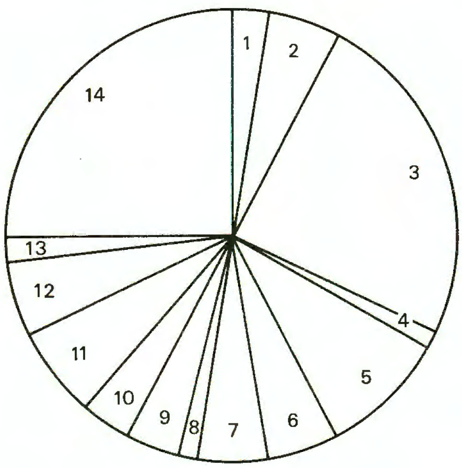
The estimated Member States' contributions towards the 1982 Budget amounted to £6,863,300. These contributions were paid according to the Scale of Financial Contributions of the 17 Member States, calculated on the basis of the Gross National Product (GNP) expressed in U.S. dollars, of each of the Member States for the years 1977, 1978 and 1979, (figures as provided by the Organisation for Economic Co-operation and Development (OECD). Table 3 shows the geographical distribution of Member States' contributions during the period 1982-1984, compared with the scale of contributions applicable in the previous 3 year period, 1979-1981.

Table 3 Geographical and percentage distribution of Member States contributions for 1979-1981 and 1982-1984

COUNTRY	% CONTRIBUTION 1979-1981	% CONTRIBUTION 1982-1984
Fed. Rep. of Germany	24.64	24.82
France	18.77	18.47
United Kingdom	12.74	12.43
Italy	9.86	10.32
Spain	5.82	5.96
The Netherlands	4.80	4.96
Belgium	3.68	3.62
Sweden	3.93	3.59
Switzerland	3.23	3.22
Yugoslavia	2.06	2.25
Austria	2.20	2.22
Turkey	2.15	2.21
Denmark	2.04	2.16
Finland	1.50	1.35
Greece	1.26	1.27
Portugal	0.87	0.69
Ireland	0.45	0.46

Staff

Dr. L. Bengtsson was appointed Director of the Centre as from 1 January 1982. F. Delsol from France, joined the Centre as Head of Meteorological Division on 1 January 1982. D. Burridge succeeded L. Bengtsson as Head of Research as from 1 March 1982. D. Söderman, Head of Operations was appointed Deputy-Director by the Council as from 1 May 1982. G. Sommeria-Klein, from France, succeeded D. Burridge as Head of Model Division with effect from 1 October 1982. At 31 December 1982 the table of staff was for 143 posts; of these 138 posts were filled, leaving five unfilled. In addition there were five visiting scientists or consultants working at the Centre. During this year the Centre continued its efforts to widen the geographical distribution of staff. Although the number of Member States represented on the staff remained the same (15), the percentage distribution improved slightly. Figure 22, and the following Table 4, show the 1982 geographical distribution of A and L grade staff. The seven posts vacant at the end of 1981 were filled during 1982, one by internal and six by external recruitment. Fourteen staff members left during 1982 and six of these vacancies were filled internally. Fourteen new staff members joined the Centre in the course of the year.



1	Belgium	2.6
2	Denmark	5.1
3	Federal Republic of Germany	24.4
4	Spain	1.3
5	France	9.0
6	Ireland	5.1
7	Italy	5.1
8	Yugoslavia	1.3
9	The Netherlands	3.8
10	Austria	3.8
11	Finland	6.4
12	Sweden	5.1
13	Turkey	1.3
14	United Kingdom	25.6

Fig. 22 Geographical and percentage distribution of A and L grade staff at 31 December 1982.

Table 4 Staff at 31 December 1982

Director	O.L. Bengtsson	Sweden
Deputy Director/Head of Operations Department	J.K.D. Söderman	Finland
Head of Research Department	D.M. Burridge	United Kingdom
Head of Administration Department	H. Hartwig	Fed.Rep. of Germany

Distribution of staff by categories and States

Country	Category	*hg	A	B	C	L	TOTAL
Belgium			2				2
Denmark			4				4
Federal Republic of Germany			18	3		1	22
Spain			1				1
France			6	5		1	12
Greece							
Ireland			4	1			5
Italy			4				4
Yugoslavia			1	1			2
The Netherlands			3	4			7
Austria			3				3
Portugal							
Switzerland				1			1
Finland			5	1			6
Sweden		1	3				4
Turkey			1				1
United Kingdom			20	38	6		64
TOTALS		1	75	54	6	2	138

*hors grade

Alpex

During 1982 the Centre hosted the International ALPEX Data Centre (IADC). On 31 December 1982, five people, including two Centre staff, were working at the IADC.

Social Security

After the exemption of U.K. staff from compulsory "Class I" contributions to the U.K. Social Security Scheme in 1981, many of the staff concerned started to pay voluntary "Class III" contributions in 1982. After some initial problems with the Department of Health and Social Security, this now works satisfactorily. During the year a survey on unemployment benefits for staff leaving the Centre was carried out in the different Member States. Twelve Member States responded to the questions in the survey. It showed that entitlement to, and the level of, benefits varies greatly from country to country. In some countries there may be no entitlement at all if staff have not contributed to a social security scheme in their home country, and in other countries there is an entitlement to substantial benefits without payment of any contributions. Negotiations were opened with the U.K. Treasury to come to an agreement for the transfer of pension rights between the Centre and the U.K. Civil Service Pension Fund, the reason being that such an agreement has been concluded between the Co-ordinated Organisations and the U.K. Treasury. As in 1981, pensions were paid to one widow and one orphan.

Co-ordinated Organisations

The Councils of four of the five Co-ordinated Organisations have agreed to full membership of the Centre so far. The Centre is now represented as an observer in the meetings of the Co-ordinating Committee of Government Budget Experts, the Standing Committee of the Secretaries General of the Co-ordinated Organisations, the Committee of Heads of Administration and the various working parties.

European School

To date all ECMWF staff who so wished have had their children accepted at the School by the Headmaster. As at the end of the year 35 children of Centre staff were at the School. The total number of children attending from the Centre now fluctuates between 35 and 40; negotiations with the governing body of the European School to ensure admission in future were continued during the year.

General Services

More time and attention were devoted by General Services staff to the maintenance of the grounds and the interior of the building, for which it had been necessary to hire contractors in the past. Nevertheless, it was necessary after four years' occupation of the building to contract out a number of large maintenance jobs, such as paintwork, redecorating, etc. Great use was made of the print-room during 1982. The total number of copies of documents printed was about 250,000, necessitating about 2 million print runs for more than one thousand different jobs.

Security

During the year the implementation of a night-time security service in place of a day-time service improved security at the Centre. The need for day-time cover during weekends and public holidays was still felt.

Restaurant

A Restaurant Committee with members from the staff was formed to liaise with the catering company on suggestions for the meals and service. The new non-subsidy contract which commenced on 1 January 1982 proved impracticable however. After the first quarter the new catering company complained that it was making losses. This led to reductions in kitchen staff and consequently to a deterioration in the level of service and the quality of the food.

Staff became more and more dissatisfied with the restaurant service and patronage dropped. A subsidy for the restaurant was requested for 1983 and approved by the Council. Market investigations have been carried out to select a suitable catering company to operate on a new subsidised contract. A contract for 1983 was concluded in December with a new catering company.

Conferences, Seminars, Meetings, etc.

The number of conferences, seminars, meetings, workshops, etc., remained about the same as in 1981. The Centre's Conference Block was used regularly throughout the year. Approximately 20 major sessions were organized during 1982. Numerous short lectures and workshops were also held in the Lecture Theatre and the Classroom.

Education

Seminars

In September the annual ECMWF seminar, this year dealing with "interpretation of numerical weather prediction products" was held. The seminar lasted for one week and was followed by a workshop which involved formal lectures and practical sessions in which workshop participants were able to verify and interpret ECMWF operational forecasts.

The seminar was mainly oriented towards statistical interpretation and verification techniques. Five external lecturers were invited, three of them coming from the Member States, to cover experience with the ECMWF products. In addition, short presentations were given by seminar participants on this subject. The seminar was attended by 30 participants from 14 Member States and was well received. Fourteen participants stayed on for the second week to participate in the workshop. Most of the workshop was devoted to laboratory sessions, during which the participants were introduced to the verification and interpretation software package developed at the Centre. The response to the workshop and to the statistical software was very positive. The participants acknowledged the flexibility of the system and regarded it as a very useful tool for future work in the Member States.

Meteorological Training Course

Nine participants from six Member States attended the ECMWF Meteorological Training Course. This training course included laboratory sessions, in which the students working in small groups used the Centre's data bases to assess the usefulness of ECMWF forecast products for local forecasting purposes. Presentations of the results were given by participants at the end of the course. An insufficient number of applications led to cancellation of the theoretical training course given in previous years.

Computer Training Course

A series of computer training courses was given to staff from Member States and internal Centre staff. They were:

Introduction to the use of the ECMWF computer facility	15-19 March and 11-15 October
Advanced use of the CRAY-1	22-26 March and 18-22 October
Use of the CYBER system	29 March-2 April and 25-29 October

A total of 30 attended, many to more than one of the courses, from 11 Member States, together with 16 Centre staff.

Workshops

Three workshops were held in the course of the year. These were as follows:

'Intercomparison of large-scale models used for extended range forecasts', 30 June - 2 July

'Data handling facilities at ECMWF', 7-8 October

'Current problems in data assimilation', 8-10 November

The Council and its Committees

Council

The Council met twice during 1982, for its 15th and 16th sessions, held on 28-29 April and 18-19 November respectively.

The representatives of the Member States at these sessions were:

State	Delegate	Session
President (Germany)	E. Lingelbach	15 and 16
Belgium	M. Deloz	15
	R. Sneyers	16
Denmark	L.B. Asmussen	15 and 16
	B. Tarp	15
	P. Thorsen	16
Germany	H.-G. Schulze	15 and 16
	P. Appel	15 and 16
Spain	P. Rodriguez-Franco	15 and 16
France	J. Labrousse	15 and 16
	J. Alt	15 and 16
Greece	S. Linardos	16
Ireland	D.L. Linehan	15 and 16
Italy	A. Zancla	15 and 16
	M. Mariani	15 and 16
Yugoslavia	F. Mesinger	16
the Netherlands	B. Kamp	15
	T. B. Voerman	15 and 16
	J. Van Tiel	16
Austria	K. Cehak	15 and 16
Portugal	L.A. Mendes-Victor	15 and 16
	R.A.C. Carvalho	15 and 16
Switzerland	G. Simmen	15 and 16
Finland	E. Jatila	15 and 16
Sweden	R. Swenson	15
	R. Berggren	15 and 16
	L. Ag	16

State	Delegate	Session
Turkey	M.C. Özgül K.Öncüler	16 16
United Kingdom	J.E. McNulty G.J. Day J. Mason	15 15 and 16 16
WMO Observer	R. Schneider	15
Icelandic Observer	H. Sigtryggsson	16

At its 16th session the Council re-elected Professor Dr. E. Lingelbach (Germany) and Dr. L.A. Mendes-Victor (Portugal) for a third year as President and Vice-President respectively.

Finance Committee

The Finance Committee met twice in the course of 1982, for its 27th and 28th sessions, held on 4-5 March and 15-17 September respectively.

The sessions were held under the chairmanship of Mr. G.J. Day (UK). At its 27th session the Committee elected Professor Dr. K. Cehak (Austria) as its Vice-Chairman. The composition of the Finance Committee during 1982 was as follows:

(i) those four Member States paying the largest financial contribution to the Centre:

Germany

France

Italy

United Kingdom

(ii) three Member States designated by the remaining thirteen Member States to represent them:

Spain

Austria

Finland

At the 15th session of the Council the appointment of these three Member States was renewed for a second term from 20 November 1982.

At its 28th session the Finance Committee re-elected Mr. G. Day (UK) and Professor Dr. K. Cehak (Austria) as its Chairman and Vice-Chairman respectively for a second year from 20 November 1982.

Scientific Advisory Committee

The 10th session of the Scientific Advisory Committee took place on 1-2 June 1982.

The members of the Committee, appointed in their personal capacity by the Council, were:

F. Mesinger	-	Chairman	Yugoslavia
C.J. Schuurmans	-	Vice-Chairman	the Netherlands
R. Bates			Ireland
F. Bushby			United Kingdom
B. Hoskins			United Kingdom
J. van Isacker			Belgium
B. Machenhauer			Denmark
J. Peixoto			Portugal
H. Reiser			Germany
R. Sadourny			France

H. Sundqvist	Sweden
L. La Valle	Italy

B. Döös was the representative of WMO at this session.

At the 16th session of the Council in November 1982, Dr. Reiser was reappointed for a second term of four years, and the two other outgoing members of the Committee, Dr. van Isacker and Professor Mesinger, were replaced by Professor E. Holopainen (Finland) and Professor H. Pichler (Austria).

Technical Advisory Committee

The Technical Advisory Committee held its fourth session on 15-18 June 1982.

All Member States are members of the Technical Advisory Committee. The representatives of each Member State in 1982 were:

Member State	Nominated Representative
Belgium	W. Struylaert
Denmark	A.M. Jørgensen
Federal Republic of Germany	W. Buschner
Spain	B. Orfila
France	J. Lepas (Chairman)
Greece	G. Barbounakis
Ireland	W.H. Wann (Vice-Chairman)
Italy	G. de Florio
Yugoslavia	M. Jovašević
Netherlands	A.P.M. Baede
Austria	G. Wihl
Portugal	S. Cristina
Switzerland	M. Haug
Finland	P. Nurminen

Sweden	L. Moen
Turkey	Director-General
United Kingdom	D.H. Johnson

Staff Association

The year began in positive fashion with a new Staff Committee and a new Director. Both the Staff Committee and the Director worked hard to ensure that the levels of consultation and negotiation were at the excellent standard that is necessary in an international organisation. The variety of problems that inevitably arise in any organisation were discussed frankly in a spirit of trust and co-operation, and sensible solutions were agreed upon.

The Staff Committee were very pleased by the willingness of many staff members to serve on sub-committees which have helped generally to maintain the high standard of working conditions at ECMWF. The Restaurant Committee in particular played an important role in the survey of prospective caterers, and this has resulted in Taylor Plan Catering Ltd taking over in the restaurant. The Staff Committee is also grateful to those who have organised a number of 'extra-mural' activities, as a result of which, staff have had the benefit of language courses and an excellent sauna suite. Regular football, squash, tennis and golf fixtures have taken place during the year.

The Director and the Staff Committee jointly organised an ECMWF birthday celebration, which turned out to be a huge success. An equally successful Christmas celebration was organised by a staff member with the support of the Staff Committee.

An important undertaking in 1982 was the establishment, in conjunction with the Director, of guidelines for a clear and fair Contract Renewal Policy. Significant progress was made in defining areas of general agreement. The Staff Committee were able to hand over a sound basis from which it is hoped an agreement will be finalised.

A strong and effective presence was maintained internationally on the various Co-ordinated Organisations' Committees. Attendance was ensured at every meeting of CPAPOC, the Standing Committee of the Staff Organisations of the Co-ordinated Organisations.

Of serious concern to CPAPOC during 1982 was the intention of the CCG, the Standing Committee of Government Budget Experts, to change quite fundamentally the provision of the 159th Report, against the wishes of both the Secretaries-General and of CPAPOC. The provisions of this Report contain the method by which the salaries and allowances of staff of the Co-ordinated Organisations are adjusted. Some of the changes proposed by government delegates implied a significantly negative impact on the present and future remuneration of staff.

A tripartite working group was set up, in which ECMWF was fully represented, to examine those proposals in depth. The negotiations that followed were extremely difficult, and the positions adopted by some government delegates led to a serious worsening of relations between the CCG on one side and the Secretaries-General and CPAPOC on the other.

Throughout this troubled time of strikes within the Co-ordinated Organisations, harmonious relations were maintained at ECMWF.

To enable this to continue undisturbed, the Committee fully supported efforts by CPAPOC to change their outmoded relations with the CCG, particularly with regard to their right of negotiation and the consultative procedures currently in use.

International Meetings and Visits

As in previous years, members of staff of the Centre have attended international meetings and conferences of relevance to the work of the Centre, and have continued to make visits to other institutes, both in order to gain knowledge and experience, and to impart it through lecturing on the Centre's own achievements.

The Centre was represented, in particular, at the following:

Workshop on the Theory and Application of Simple Short-Term Climate Models, KNMI, De Bilt, Netherlands (March)

Symposium über Strahlungstransport probleme und satellitenmessungen in der Meteorologie und Ozeanographie, Cologne, FRG (March)

Joint Scientific Committee, 3rd Meeting, Dublin, Ireland (March)

Regional Association VI (Europe) Working Group on Meteorological Telecommunications, Thirteenth Session, Geneva, Switzerland (March-April)

Working Group on Numerical Experimentation, 4th meeting, Exeter, UK (April)

JSC Study Conference on Observing System Experiments, Exeter, UK (April)

VIM/ECODU, St.Paul, Minnesota, USA (April)

International symposium on local computer networks, Florence, Italy (April)

ALPEX, Joint Scientific Committee working group meetings, Geneva, Switzerland (April and September)

International Union of Geodesy and Geophysics, inter-union, international conference on Mathematical Geophysics at Château de Bonas, France (June)

American Meteorological Society 14th Technical Conference on Hurricanes and Tropics, San Diego, California, USA (June)

Royal Society (London) meeting on the Results of the Royal Society Joint Air-Sea Interaction Project (JASIN), London, UK (June)

Nordic Meteorological Meeting, Copenhagen, Denmark (June)

WMO, Executive Committee, 34th Session, Geneva, Switzerland (June)

4th International Conference on Finite Elements in Water Resources, Hanover, FRG (June)

14th Stanstead Seminar, Lennoxville, Canada (July)

CBS Working Group on the Global Telecommunications System, Tenth Session, Geneva, Switzerland (July)

NATO Advanced Study Institute on Mesoscale Meteorology, Château de Bonas, France (July)

European Geophysical Society 9th Meeting and Symposium on Predictability of Geophysical Fluid Systems, Leeds, UK (August)

ECODU-34, Alborg, Denmark (September)

XIX Reunion Bienal RSEFQ, Santander, Spain (September)

Informal WMO meeting of experts on The Development of the PWPR Study Projects, ECMWF, Reading, UK (September)

NOAA 7th Climate Diagnostics Workshop, Boulder, Colorado, USA (October)

IFEE Fifth Symposium on Mass Storage Systems, Boulder, Colorado, USA (October)

Cray User Group, Sante Fe, New Mexico, USA (October)

Future Software Advisory Board, Minneapolis, USA (October)

Eurographics, Manchester, UK (October)

4th Meeting of the European Working Group on Limited Area Modelling, Paris, France (October)

WMO - Commission for Atmospheric Sciences Joint Scientific Committee Expert Study Meeting on Long-Range Forecasting, Princeton, USA (December)

Working Group on Numerical Experimentation, 5th Meeting, Princeton, USA (December)

WMO/IAMAP Meeting on Aerosols in Numerical Models, Lille, France (December)

In addition to this, members of staff visited a number of universities, meteorological institutes and other institutions such as National Meteorological Centre, Washington, DC, USA; Geophysical Fluid Dynamics Laboratory, Princeton, USA; National Centre for Atmospheric Research, Boulder, Colorado, USA; Laboratoire de Météorologie Dynamique, Paris; European Space Agency, Darmstadt and Paris; Goddard Laboratory for Atmospheric Sciences, Maryland, USA; National Earth Satellite Service, USA; Space Sciences and Engineering Centre, University of Wisconsin, USA; CRAY and CDC, USA; European Space Operations Centre, Darmstadt; Fleet Numerical Oceanography Centre, Monterey, California, USA and the Air Force Global Weather Centre, Omaha, Nebraska, USA.

The programme of visits to the national meteorological services of the Member States was completed during the year; all seventeen Member States' services have been visited over the last two years.

Annex 1

ECMWF Publications 1982

Technical Reports

No. 29 Orographic Influences on Mediterranean Lee Cyclogenesis and European Blocking in a Global Numerical Model

No. 30 Review and Re-assessment of ECNET - a private network with open architecture

No. 31 An Investigation of the Impact at Middle and High Latitudes of Tropical Forecast Errors

No. 32 Short and Medium Range Forecast Differences Between a Spectral and Grid Point Model - An Extensive Quasi-Operational Comparison.

No. 33 Numerical Simulations of a Case of Blocking: the Effects of Orography and Land-Sea Contrast

No. 34 The Impact of Cloud Track Wind Data on Global Analysis and Medium-Range Forecasts

Seminar Proceedings

Problems and Prospects in Long and Medium Range Weather Forecasting, 14-18 September 1981

Workshop Proceedings

Tropical Meteorology and its Effect on Medium Range Prediction at Middle Latitudes, 11-13 March 1981

Parameterization of the Planetary Boundary Layer in Numerical Models, 25-27 November 1981

GARP - FGGE

Daily Global Analysis - Part III June 1979-August 1979

Daily Global Analysis - Part IV September 1979-November 1979

ECMWF Newsletter

No. 13	February
No. 14	April
No. 15	June
No. 16	August
No. 17	October
No. 18	December

ECMWF Computer Bulletins

New Features of Fortran 77

Bit Operations in Fortran

Debugging Graphical Jobs

CONVAR - a grid interpolation package

FORMAL reference manual

COMMAND

Permanent File Disc Facilities

ARCHSET - A User Archiving Package

ECMWF Forecast Reports

No. 14	April-June 1981
No. 15	July-September 1981
No. 16	October-December 1981
No. 17	January-March 1982
No. 18	April-June 1982
No. 19	July-September 1982

ECMWF Meteorological Bulletins

Retrieval utility for ECMWF databank for reports and fields on standard pressure levels (GETDATA)

Utility for retrieval under non-chargeable account from ECMWF databank of reports and fields on standard pressure levels (FINDATA)

GETDATA retrieval of WMO-CAS intercomparison data.

Other Publications

ECMWF Forecast Model Documentation Manual

Annex 2

Publications by Members of Staff

Bengtsson, L. 1982 Numerical modelling of the global atmosphere. Proceedings of the 4th International Conference on Finite Elements in Water Resources, Hannover. *Springer-Verlag, Berlin, Heidelberg, New York 1982.* 1-3 - 1-27.

Bengtsson, L., Kanamitsu, M., Kållberg, P. and Uppala, S. 1982 FGGE 4-Dimensional Data Assimilation at ECMWF *Bulletin of the American Meteorological Society, 63,* 29-43.

Bengtsson, L., Kanamitsu, M., Kållberg, P. and Uppala, S. 1982 FGGE Research Activities at ECMWF *Bulletin of the American Meteorological Society, 63,* 277-303.

Bengtsson, L., Böttger, H. and Kanamitsu, M. 1982 Simulation of hurricane-type vortices in a general circulation model. *Tellus, 34,* 441-457

Bengtsson, L. 1982 The global weather experiments. Results and proposals for future observing systems. Proceedings from the 14th Stanstead Seminar 1982.

Bengtsson, L. 1982 Performance and limits of global models in the Mediterranean, *Rivista di Meteorologia Aeronautica, Volume XLII N 2/3* 123-142

Dell'Osso, L. 1982 ECMWF Limited Area Model, *Rivista di Meteorologia Aeronautica, Volume XLII N/3,* 273-284.

Dell'Osso, L. and Tibaldi, S. 1982 Some preliminary modelling results on an ALPEX case of lee-cyclogenesis in ALPEX preliminary scientific results, *GARP-ALPEX Vol. I WMO-Geneva.*

Geleyn, J-F., Girard, C. and Louis, J-F. 1982 A new parameterization for moist convection in a multi-layer model of the atmosphere, *Beiträge zur Physik der Atmosphäre, 55,* 325-334.

Geleyn, J-F., Hense, A. and Preuss, H.J. 1982 A comparison of model generated radiation fields with satellite measurements, *Beiträge zur Physik der Atmosphäre, 55,* 253-286.

Geleyn, J-F., Jarraud, M., Labarthe, J.P. 1982 La prévision météorologique a moyen terme, *La Recherche, 13,* 324-338.

Heckley, W.A. and Hoskins, B.J. 1982 Baroclinic waves and frontogenesis in a non-uniform, potential vorticity semi-geostrophic model, *Journal of the Atmospheric Sciences, 39,* 1999-2016.

Hoffmann, G.R. 1982 Special Considerations for a CRAY Installation *Das Rechenzentrum 5,* 164-170.

Louis, J-F. 1982 Parameterization in atmospheric models, *Rivista di Meteorologia Aeronautica, Volume XLII N 2/3,* 219-253.

Oriol, E. 1982 El cielo energetico de la atmosfera en las predicciones del ECMWF. Proceedings XIX Reunion Bienal RSEFQ, Santander, 119-120.

Simmons, A.J. 1982 The forcing of stationary wave motion by tropical diabatic heating, *Quarterly Journal Royal Met.Soc., 108*, 503-534.

Simmons, A.J. 1982 The numerical prediction and simulation of the tropical atmosphere - a sample of results from operational forecasting and extended integrations at ECMWF. *Tropical Droughts: Meteorological aspects and implications for Agriculture. R.P. Pearce (Ed) WMO Geneva*, 81-103

Tibaldi, S. 1982 The production of a high resolution global orography and associated climatological surface fields for operational use at ECMWF, *Rivista di Meteorologia Aeronautica, Volume XLII N 2/3*, 285-308.

Tibaldi, S. 1982 Humidity analysis at ECMWF, *Rivista di Meteorologia Aeronautica, Volume XLII N 2/3*, 309-328.