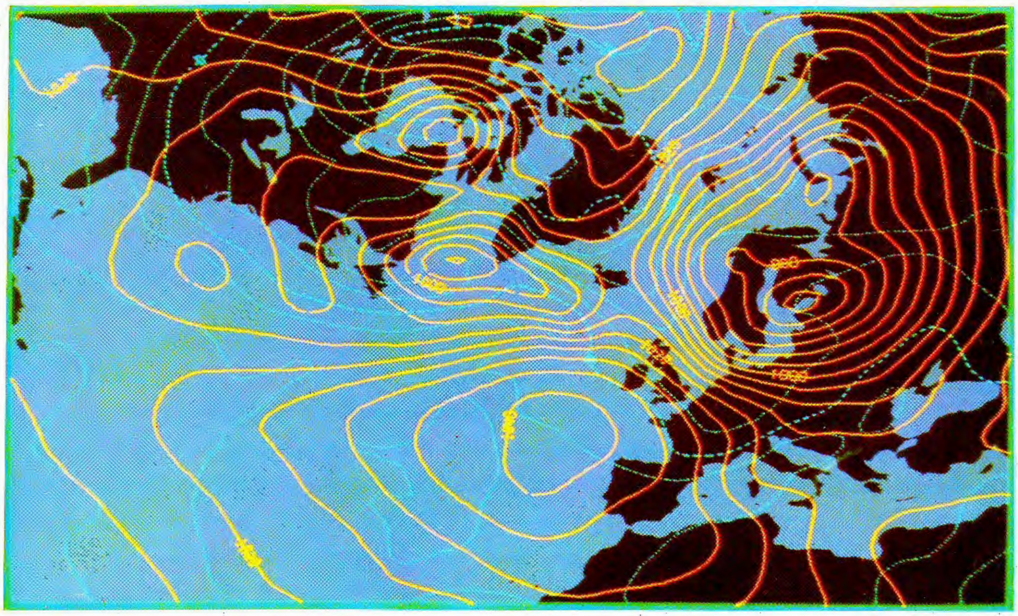
Annual Report 1981



European Centre for Medium Range Weather Forecasts

Contents

Abbreviations

The following abbreviations are used in the text of this Annual Report:

CCG	Co-ordinating Committee of Government Budget Experts of the Co-ordinated Organisations
EPO	European Patent Office
Eumetsat	European Meteorological Satellite Organisation
FGGE	First GARP Global Experiment
GARP	Global Atmospheric Research Programme
GATE	GARP Atlantic Tropical Experiment
GKS	Graphics Kernel System
GNP	Gross National Product
GTS	Global Telecommunications System
N (as in e.g. N48)	No. of grid-lengths between equator and pole (= 48)
NFEP	Network Front End Processor
PACX	Private Automatic Computer Exchange
RTH	Regional Telecommunications Hub
T (as in e.g. T63)	Triangular truncation at total wavenumber (63)
WMC	World Meteorological Centre

Foreword

1981 may correctly be denoted the first fully operational year of the Centre, with the distribution of daily forecasts for up to 7 days, over the whole year.

The year has seen other developments at the Centre, with additions and upgradings to the telecommunications network between the Centre and the Member States, and, in November, the arrival of a second Cyber computer (CYBER 730E) to enlarge the potential of the Centre's computer system.

1981 has also been a fruitful year for the research work necessary to achieve finally reliable forecasts for up to ten days. I am confident that with the expertise and enthusiasm we see in the Centre this goal will be more nearly approached in 1982. It has, of course, been very difficult in the prevailing economic situation to reconcile the needs of the Centre to carry out these plans with the financial potential available in the Member States. Nevertheless, I am optimistic that substantial progress will be made under the programme of activities that has been agreed upon.

My year as President of the Council has brought me into even closer collaboration with the Director of the Centre and his staff, and I would like to say how grateful I am for all the assistance I have received from all of them. I have also greatly appreciated the hard work and constructive advice from the Committees of the Council, and in particular their Chairmen. Having been re-elected at the last Council session to serve as President again, I look forward to another year of cheerful and fruitful co-operation with all those associated in the work of the Centre.

Regarding the overall achievement in 1981, the details of which you will find in this report by the Director, I wish to congratulate all concerned on behalf of the Council.

Dr. E. Lingelbach

Introduction

This year has been one of consolidation for the whole Centre. Reorganisation of the Administration has led to greater efficiency and provision of a better service. In the Operations Department services to the Member States, both in the meteorological and in the computing field, have been improved.

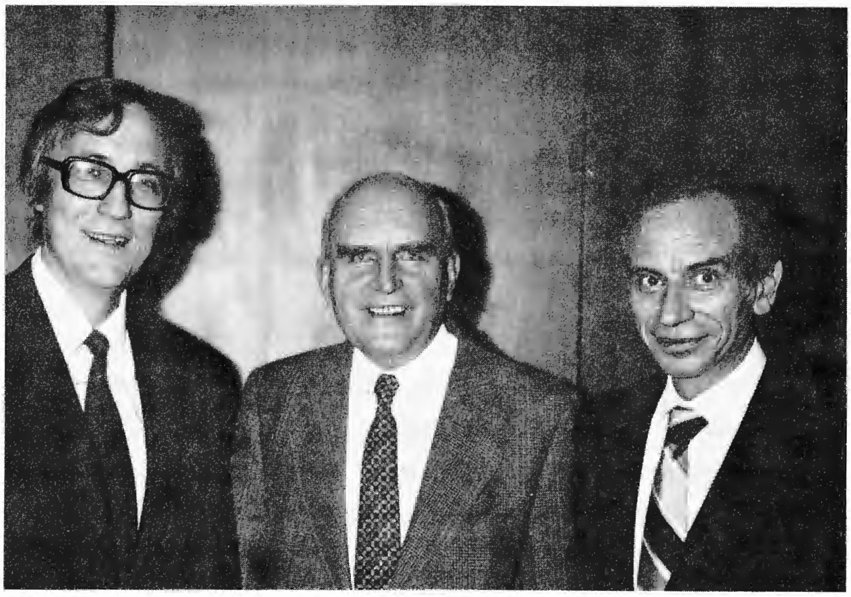
A considerable effort has been made in trying to find methods for better use of the numerical forecasts. This has been done with the assistance and collaboration of the Member States.

In the field of activity of the Research Department, the main event has been the establishment of a new programme of work which should, in about five years' time, culminate in a new generation of models. With a view to reaching this target, a detailed spectral version of the present model has been designed, to be put into operation late in 1982.

As I leave the Centre to take up a new appointment in my home country, I am confident that under the leadership of the new Director, and with the contributions of the excellent staff of the Centre, all these projects will lead to a considerable improvement in the quality of the Centre's products over the next five years.

J. Labrousse

Director of the Centre



Dr. Lennart Bengtsson, incoming Director of ECMWF.
Professor E. Lingelbach, President of the Council of ECMWF.
Mr. J. Labrousse, outgoing Director of ECMWF.

In November 1981 the Director of the Centre, Mr. Jean Labrousse, announced his departure from the Centre, to take up an appointment as Director of the French Meteorological Service. At its 14th session held on 19 - 20 November 1981, the Council appointed as his successor Dr. Lennart Bengtsson, who had been Head of the Research Department since the Centre's establishment in November 1975.

The President of the Council, Professor Dr. E. Lingelbach was present at a party held on 15 December 1981 to bid farewell to Mr. Labrousse, and to welcome Dr. Bengtsson into his new post. His speech on that occasion was made on behalf of all the Council, and was as follows:

"Dear Colleagues,

I have the honour to be here today in the name of the Council of the European Centre for Medium Range Weather Forecasts. Two duties have been assigned to me. First, to thank the leaving Director Jean Labrousse for all the services he has rendered to the Centre for the benefit of the 17 Member States and meteorology in general, and secondly to introduce the new Director Lennart Bengtsson into his new office.

Monsieur Labrousse, you have joined the staff of this Centre in its very early days. Since July 1974 you have worked for this European institution. First in an informal planning group and later, from first of January 1976 as Head of the Operations Department. You were also appointed deputy to the first Director of the Centre, Aksel Wiin-Nielsen, together with Lennart Bengtsson. Your excellent knowledge of computers and telecommunications was always of great importance, to the Centre especially in the planning stage.

When you became Director of the Centre in 1979, you were very well prepared. Your scientific education, your experience in your home service, but especially the knowledge you had gained during the 5 years of hard work in the Centre, made you the favourite candidate for this outstanding position. And the Council's choice was a very good one! At the time of the appointment the Council felt that way, today the Council knows it for sure.

With your great skill and your ability to recognize the important problems you always have found workable solutions for the Centre. Especially in the last two years with its great financial difficulties this has not been an easy task. Nobody knows this better than most of the members of the Council, and of course the President himself. Many times in the past it has been mentioned that in the years since its very beginning the Centre has had an outstanding success not only as far as Europe is concerned but also regarding all meteorological centres of the whole globe. This is of course due to all colleagues working in this Centre, women and men alike, but a great part of it is certainly your merit. It is my privilege today to thank you for this in the Council's name.

I can imagine that the decision to leave or to stay has not been easy for you when your Government called upon you. Now you have decided, and I think everybody will honour your decision. We lose you here as Director, and we feel somehow sorry but we win you as Director of the Météorologie Nationale, and we are sure that besides the many duties you will have in taking over your new office, you will also take care of the well-being of the Centre. In the name of the Council, Monsieur Labrousse, I wish you good luck in your new position, and I am sure success will come to you as it has come in the past.

Et à la fin, Jean Labrousse, laissez-moi dire quelques mots personnels. Beaucoup de fois nous avons discuté des problèmes. Pour moi c'était presque toujours un plaisir, parce que j'ai admiré votre logique française et votre humeur gallic! Et je crois que tous les deux, nous avons été contents chaque fois d'avoir trouvé une solution acceptable.

Jean Labrousse, je vous souhaite des années heureuses dans votre pays, et j'espère d'avoir l'opportunité de vous voir de temps en temps aussi dans ce Centre-ci.

Mr. Bengtsson
I am twofold happy now, first of all that we have already found a new Director for the Centre and secondly, that you are the one we have chosen.

Everybody knows you. And I think it would mean bringing coals to Newcastle explaining your abilities to the audience. Nevertheless let me remind you of a few facts.

Like Jean Labrousse you joined the Centre in 1974 and I mentioned already, that you became Deputy-Director together with him in 1976 when you were appointed as Head of the Research Department.

You know the tasks of the Centre very well. You know the technical, the financial, but first hand also the scientific problems and you have demonstrated more than once that you have also the knowledge and ability to attack those problems and solve them, if necessary step by step. And you are not alone. You have a helping force here of men and women, I think it is no exaggeration, to call it a potential unique in the world. And you have also 17 nations behind you. Even if these Member States will ask you from time to time to be as economical as possible, you can be sure that all those European Nations wish to see the best results possible of this institute they have founded having in mind the tremendous economic value of medium range weather forecasts, and all those members know very well that this has its price.

You have a good start with the new programme and budget for the Centre the Council decided upon last November. Good luck, Lennart Bengtsson. Very soon you will be the Director of one of the best meteorological institutes I can think of. Use it with your colleagues to the benefit of our science and to the benefit of the economies of our Member nations."

Operations Department

The first priority of the Operations Department during the year has been consolidation of, and improvement to, the computer and meteorological services to the Member States. Forecasts to ten days have been produced daily throughout the year; not one forecast was missed. The number of forecast products disseminated to Member States increased from 2,700 per day at the beginning of January to nearly 7,000 per day at the end of the year.

Operational Forecasting

The primary task of the Operations Department is the daily production of medium-range weather forecasts. Figure 1 shows schematically the daily operational schedule. Data acquisition takes place intermittently throughout the 24 hours as data become available on the Global Telecommunications System (GTS). Pre-processing of the data, including quality control and insertion of the data in the Reports Data Base, is carried out at times which cause minimum interference with

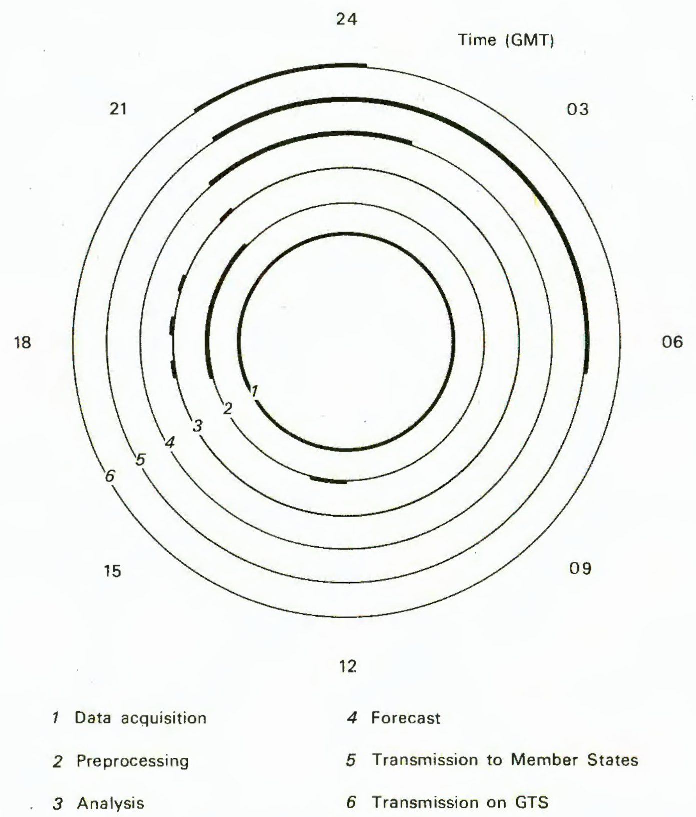


Fig. 1 ECMWF daily operational schedule, showing average times of data acquisition and data preprocessing, analysis and forecast production and times of dissemination of products during July-December, 1981.

batch usage of the computer system by Member States or others. The four analysis cycles, for 18Z the previous day, then for 00Z, 06Z and 12Z on the current day, are carried out during the evening, with 2045Z the data cutoff time for the last 12Z analysis.

During the remainder of the day, the computer system is available for other use, including that by scientists from Member States via their RJE links or when visiting the Centre, and by the Research Department at ECMWF.

A forecast to 10 days was produced for each day of the year. Of all forecasts, 90% were completed within 1 hour of the normal completion time, and only 14 forecasts were delayed by more than 3 hours.

Telecommunications

Figure 2 shows the ECMWF network and its links to Member States and to the Global Telecommunications System (GTS) of the World Meteorological Organisation (WMO). Observational data are received from the GTS and ECMWF products are inserted onto the GTS via both RTH Offenbach and RTH Bracknell.

Five new medium speed (2400 or 4800 bps) connections to Member States became operational during the year and a sixth was being tested at the end of the year. More than half the Member States now have such medium speed connections, and at the end of 1981 only five Member States were dependent on low speed lines for receipt of ECMWF products. The planned dates to implement medium speed lines to the five remaining Member States are: Spain, February 1982; Italy, January 1983; Greece, May 1982; Yugoslavia, July 1983; and Turkey, January 1985. Direct medium speed connections are planned for Belgium and for Switzerland in July 1984.

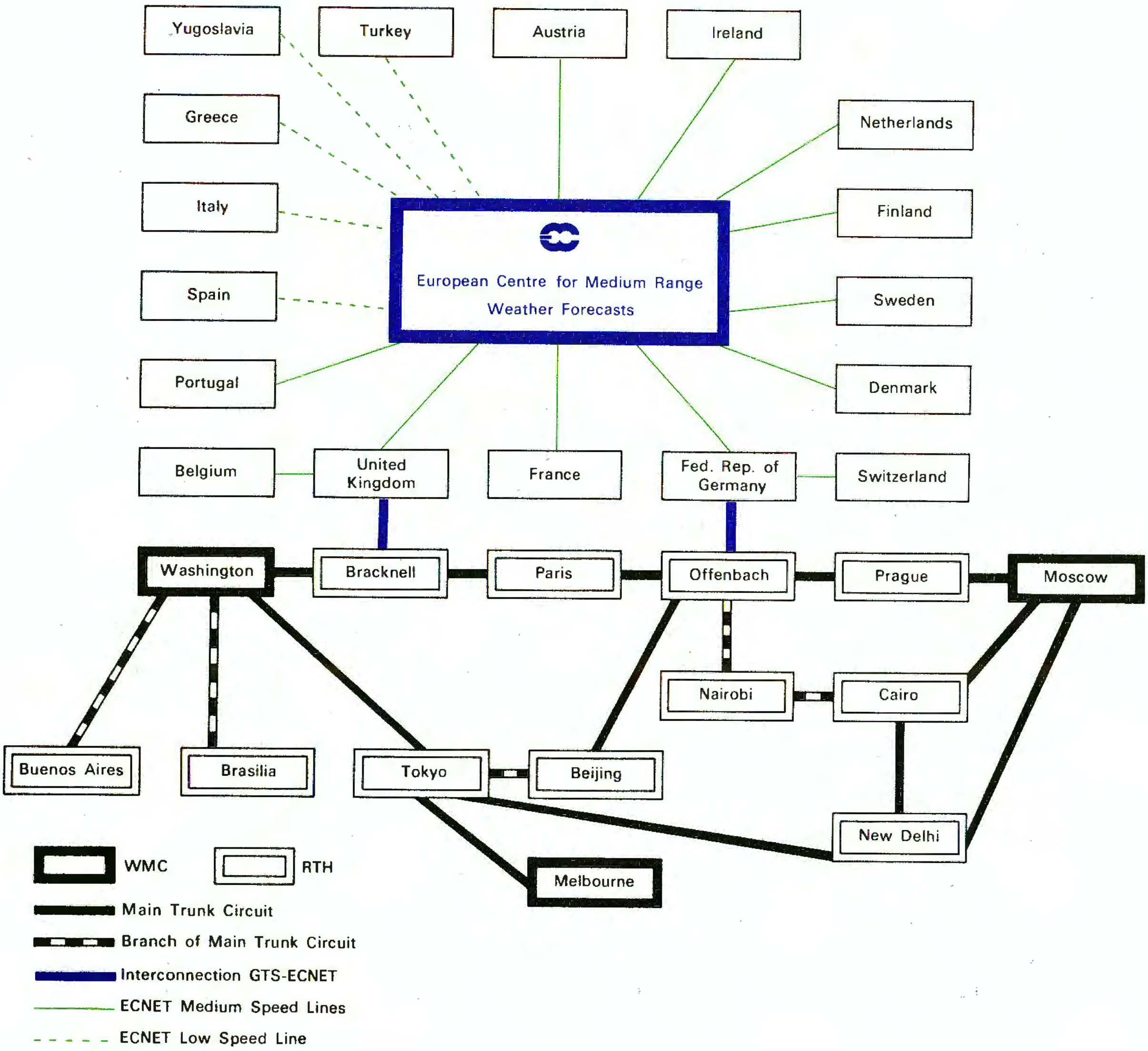


Fig. 2 The ECMWF network (ECNET) at December, 1981 and the Global Telecommunications System (GTS) of the World Meteorological Organisation.

Dissemination from ECMWF

Analysis and forecasts products are disseminated to Member States and onto the GTS as they become available during the evening and night, (see Figure 1). Figure 3 shows the rapid increase in the total number of products disseminated to Member States during the year.

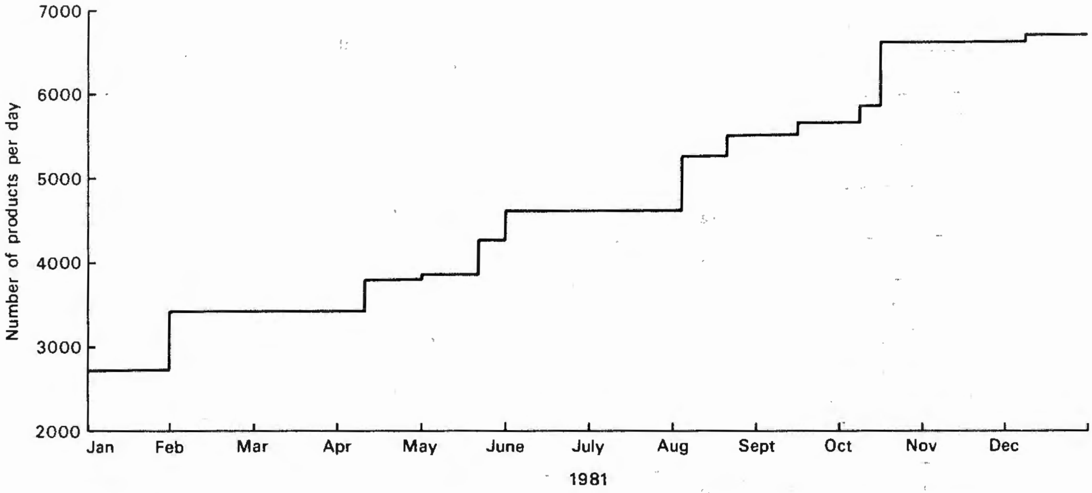


Fig. 3 Total number of products disseminated each day to Member States during 1981.

Table 1 shows in detail the range of ECMWF products disseminated on the GTS and thus available to the world meteorological community, as from 1 August 1981.

Table 1 Range of ECMWF products distributed on the Global Telecommunications System from 1 August 1981

Area	Parameter and Level	Time Step
Northern Hemisphere (20°N to pole)	Surface pressure 500 mb geopotential height	analysis to D+5 forecast
Tropical Belt (35°N to 35°S)	850 mb wind 200 mb wind	analysis only
Southern Hemisphere (20°S to pole)	Surface pressure 500 mb geopotential height	analysis to D+4 forecast

The Computer Service in 1981

Consolidation of the computer service was the keynote of 1981. Special attention was paid to bringing reliability to a high level to ensure the timely production of the operational forecast. The performance of the mainframes in 1980 and 1981 is shown in Table 2, their usage in Table 3. Figure 4 shows the changing pattern in use through the year.

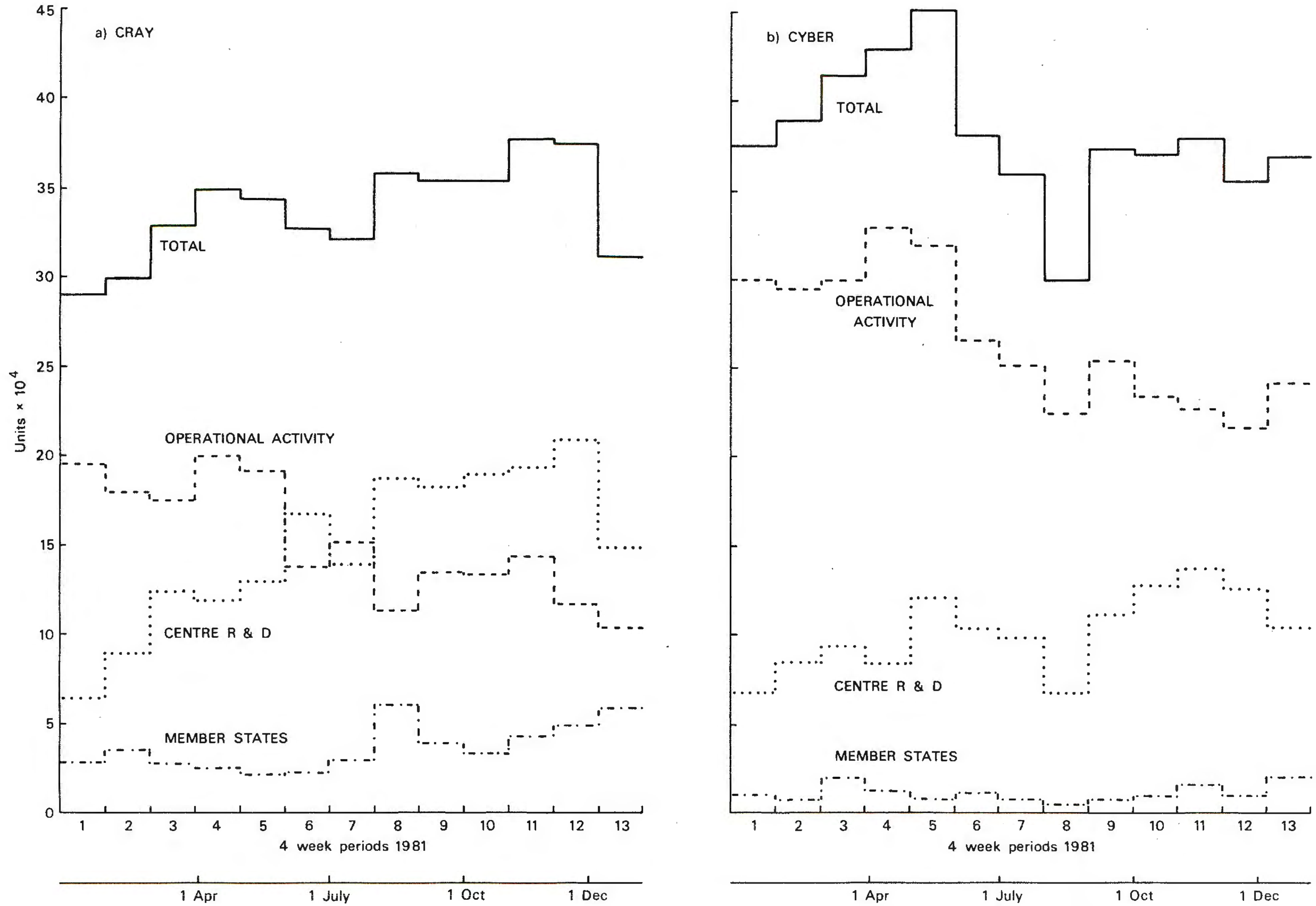


Fig. 4 a) Cray b) Cyber units used per four-weekly period during 1981.

Table 2 Performance of the CRAY-1 and CYBER 175 in 1981 (figures for 1980 in parentheses)

	CRAY-1	CYBER 175
Number of jobs run (thousands)	199 (191)	1230 (1138)
Number of computing units used (million units)	4.4 (4.2)	5.0 (3.9)
Number of hours of central processor time	4493 (4185)	3881 (3520)
Average availability (%)	98.9 (98.5)	99.4 (97.6)
Mean time between hardware faults (hrs)	78.8 (75.2)	119.2 (118.4)
Mean time between software faults (hrs)	129.5 (111.9)	123.7 (100.5)
Mean time between any faults (hrs)	71.4 (45.2)	95.7 (78.0)

Table 3 Computer usage in 1981 K units (1980 usage in parentheses)

	CRAY-1	CYBER 175
Member States	484 (315)	136 (134)
Member States special projects	2 (3)	9 (9)
Operational forecast production	1457 (1334)	2876 (1534)
Operational forecast trials	236 (369)	275 (260)
FGGE	291 (473)	318 (515)
Centre Research and Development	1984 (1696)	1347 (1405)
Overall TOTAL	4418 (4190)	4961 (3857)

Computer Developments

To provide an acceptable level of service, enabling the scientific programme of the Centre to proceed unhindered, several developments took place through the year. These included:

- installation of additional Cyber discs (model 885s), effectively doubling the on-line capacity;
- increasing the Cray on-line disc capacity by 75%; this had the beneficial effect of reducing considerably the Cray-Cyber link traffic;
- enhancement of the Centre's in-house terminal system with an upgraded Private Automatic Computer Exchange (PACX), and additional terminals. There is now sufficient capacity to allow one terminal per programmer office, increasing the productivity of programming staff;

- continued upgrading of the operating systems to provide more benefits for the users, including improvements to the efficiency of the system;

- provision of further software tools to speed up the design, coding testing and implementation of user software;

- provision of Fortran compilers at the new ANSI 77 standard level on both machines. This new standard provides many features to improve coding, making it possible to write programs faster, to maintain them more easily;

- setting up of measuring tools on both machines to monitor continuously the performance of each machine, allowing inefficient programs to be rapidly spotted and rectified;

- introduction of version 2 of the operational suite supervisor (this supervises the many hundreds of individual jobs which are run each day during the operational forecast);

- duplication of the NFEP (Network Front End Processor) system, providing a very high level of reliability.

At the end of the year the Centre took delivery of a CDC CYBER 730E. This will considerably ease the burden on the existing Cyber 175, especially its interactive workload. The new machine will be brought into service early in 1982.

The configuration of the ECMWF computer systems at the end of the year is shown in Figure 5.

Graphical Facilities

The Centre's operational graphical facilities continue to be used very effectively, with especially heavy use being made of the Versatec electrostatic plotter system.

Two major developments are under way to keep up with the known growth in demand, and provide better facilities to enable the scientific evaluation of both operational and experimental forecasts to be speeded up considerably. The first is the creation of graphics software based on the draft proposed international standard GKS (Graphic Kernel System) sponsored by DIN (Deutsches Institut für Normung). The main design is complete (based on GKS 7.0), and workstations are being developed for different devices. This will lay the foundations for several improvements on the existing software.

The second is the Aydin colour graphics display terminal, which has been developed to the point where trial meteorological charts can be displayed, and some simple sequences can be animated. At the end of the year a meteorological workstation, based on the Aydin device, was being implemented to provide a test bed for use by meteorological analysts. An example of a display on the Aydin terminal is

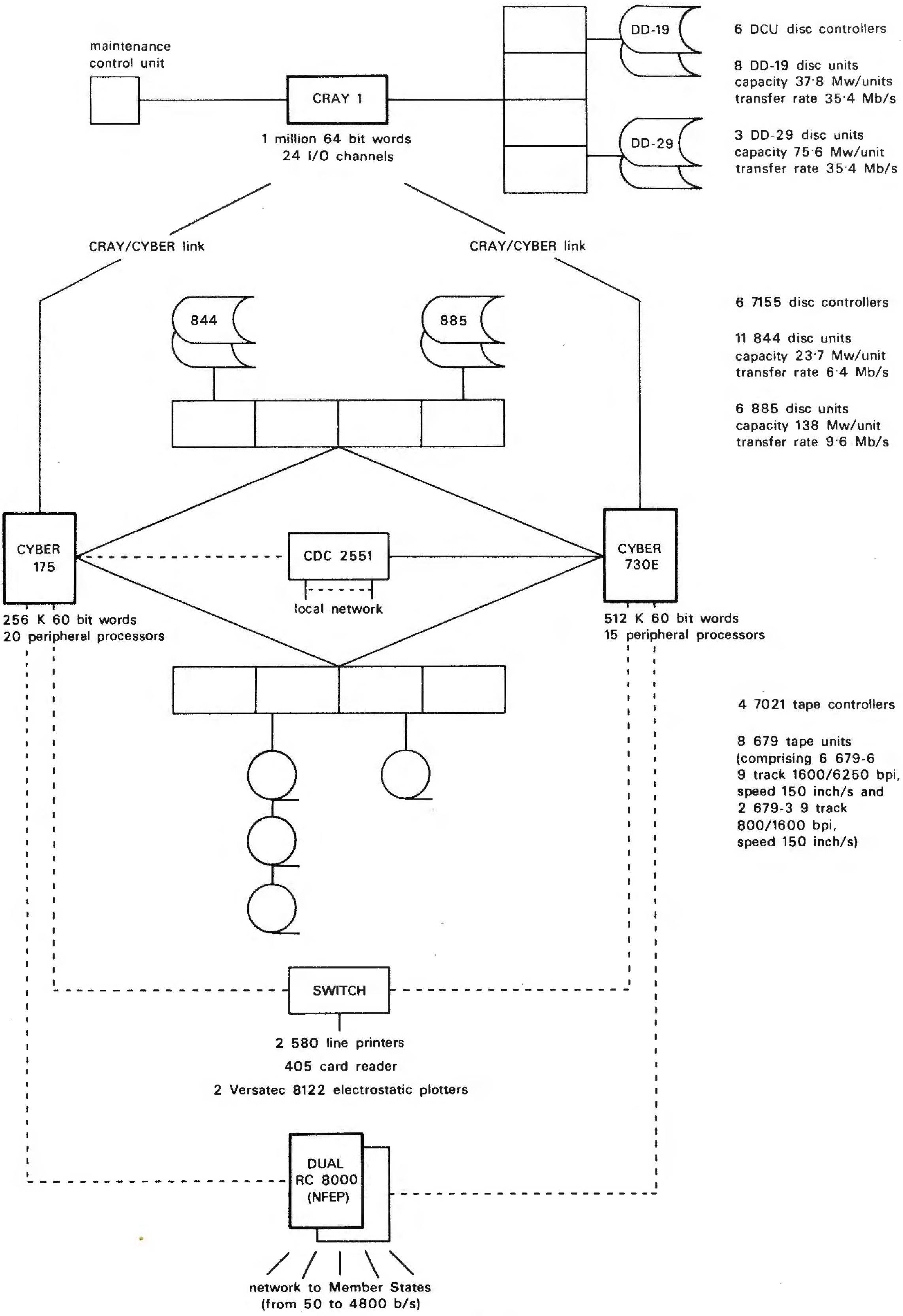


Fig. 5 Configuration of ECMWF Computer System.

featured on the cover of this Annual Report.

Assessment and Verification of the Centre's Forecasts

The Centre's forecasts are assessed objectively, using conventional verification scores such as anomaly correlation, root mean square error and correlation of tendencies for various parameters, including geopotential height and temperature for several areas, e.g. hemispheric regions and smaller areas such as the European area. Figure 6 shows the continuing improvement in the ECMWF forecasts in the medium range. It can be seen that the D+5 forecasts for 1981 for the Northern Hemisphere (area 18N-78N, 0-360E) are as good or better for each month of that year compared to 1980. It can also be seen that the values of the 1981 D+5 scores were above the 60% level, this being generally regarded as the measure of a useful forecast, for each month of the year.

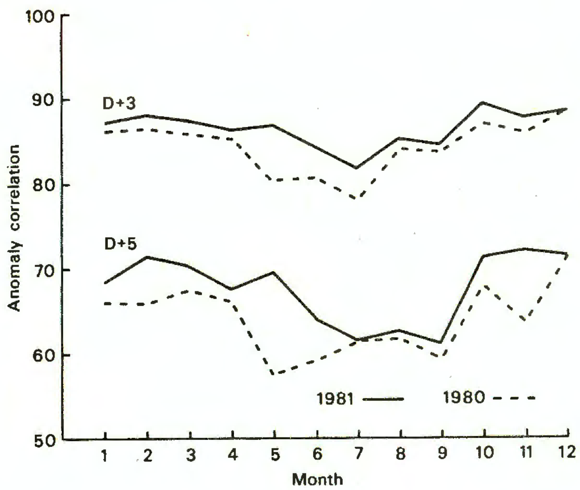


Fig. 6 Verification of D+3 and D+5 500 mb geopotential height scores for the Northern Hemisphere (area 18°-78°N; 0°-360°E) for 1981. The 1980 scores are plotted for comparison.

Figure 7 shows the mean anomaly correlation of height scores for the European area for 1981, with persistence plotted for comparison. The 60% score at the 500 mb level was reached at about D+5½, on average, for the forecasts, compared with about D+1¾ for persistence.

In Figure 8, it can be seen that 50% of the D+5 forecasts at 1000 mb over Europe have an anomaly correlation score of 60% or better. These scores refer to direct model output of individual forecasts; there are indications that useful information can be extracted from the later stages of the forecasts by statistical methods or (see for example, Figure 12) by use of mean fields.

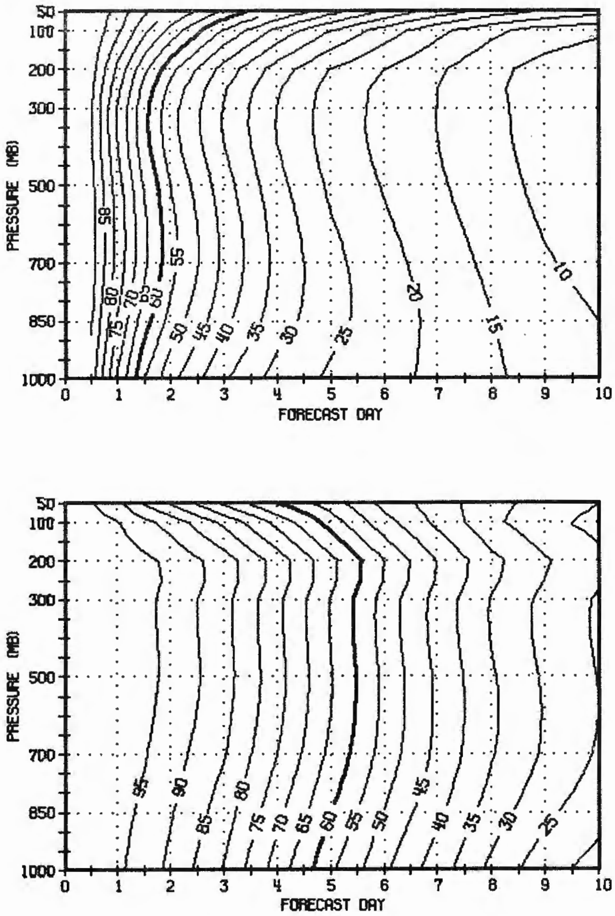


Fig. 7 *Mean anomaly correlation scores for geopotential height for persistence (top) and for forecasts (bottom) for the European area (36°-72°N; 12°-42°E) for 1981.*

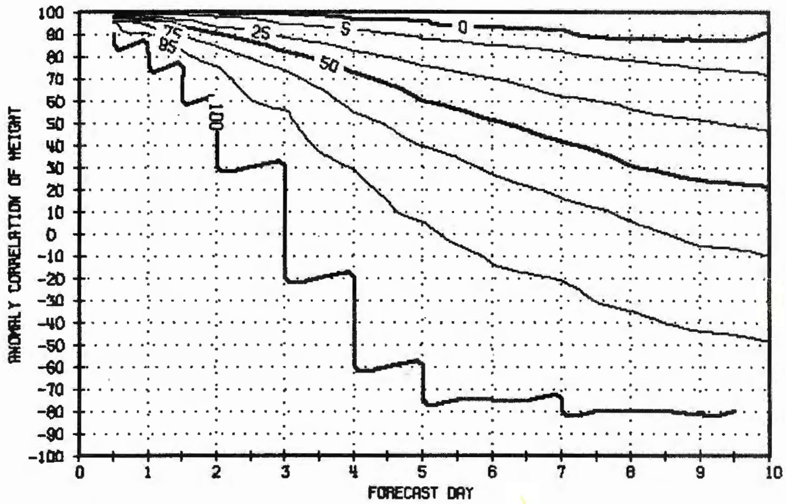


Fig. 8 *Percentage cumulative distribution for mean anomaly correlation scores at 1000 mb for the European area (36°-72°N; 12°W-42°E) for 1981.*

Contacts with Member States

Member States are placing growing reliance on the Centre's products and computer service, and good person to person communication between Member States and Centre staff is becoming essential. Several positive moves were made in this direction, including:

- visits to meteorological services of the Member States to present meteorological seminars and discuss with the staff concerned their experience with and use of ECMWF products. Such visits were made to the meteorological services of Spain, Greece, Italy, Yugoslavia, the Netherlands and Portugal in 1981; visits to the other Member States are planned for 1982;

- designation of meteorological Contact Points within the Member States. These facilitate the liaison and exchange of information of meteorological and operational interest in relation to the Centre's operational products;

- appointment of computer user support staff to act as Contact Points for specific Member States. These Contact Points aid and assist Member States on all aspects of using the Centre's computer facilities;

- design of a comprehensive message service, based on the Network Front End Processor (NFEP). It is planned to implement this service in 1982.

Use of ECMWF Forecasts in the Member States

At a meeting of Forecasters from Member States, held at ECMWF on 18-19 May 1981, it was concluded that

> *"The Centre's products have become essential and integral parts of routine operational medium-range forecasting in the majority of Member States."*

Examples of the use of medium-range forecasts in the Member States include forecasts issued to the media, including radio, TV and newspapers, to energy companies, the building industry, land-surveying authorities, ice-breaking services, harbours and shipyards, agriculture, railways and snow-clearance authorities.

Consultants and Visiting Scientists

During 1981, the Operations Department employed the following consultants, visiting scientists, and experts:

Dr. J. Almond	Universität Stuttgart, Germany
Dr. T. Bloch	CERN, Geneva, Switzerland
Mr. R. Buhtz	Freie Universität Berlin, Germany
Dr. A. Ducrot	INRIA, Paris, France
Dr. R. Field	University of London Computer Centre, United Kingdom
Dr. M. Grave	INRIA, Paris, France
Mr. P. Gray	Lawrence Livermore Laboratory Berkeley, California, USA
Dr. S. Grønås	Norwegian Meteorological Institute, Oslo, Norway
Mr. G. Hopkins	Mitre Corporation, USA
Professor W. Jensen	Tromsö University, Norway
Dr. J. Larmouth	University of Salford, United Kingdom
Dr. G. Lee	CERN, Geneva, Switzerland
Mr. F. Lewis	Washington, DC, USA
Mr. A. Murphy	Oregon State University Department of Atmospheric Sciences Corvallis, Oregon, USA
Dr. D.A. Robertson	Recherche en Prévision Numérique Pêches et Environnement, Dorval, Canada
Mr. M. Roth	Swiss Meteorological Institute, Zürich, Switzerland
Mr. J. Schönhut	Universität Erlangen, Germany
Mr. R. Uhlig	Bell Northern, Canada
Dr. I. Watson	University of Manchester, United Kingdom

Research Department

Development continued on all aspects of the operational system during the year. Plans are well advanced for the testing of a new forecasting system in 1982. The main feature will be the replacement of the grid point model by a spectral model. Work also continued on theoretical studies of problems in large scale dynamics in order to provide guidance for the experimental work. The analysis of the data for FGGE (December 1978 - December 1979) was completed.

Data Assimilation

Several improvements have been made to the data assimilation scheme; these improvements have been introduced into operations, and into the FGGE analyses, where appropriate. A typical assimilation cycle can be considered as having three main steps - the generation of a first guess field (normally a 6 hr forecast from a preceding analysis); an analysis of mass, wind and humidity; and an initialization, to achieve a state of balance suitable for the subsequent model forecast. There is now a better appreciation of the separate roles of these three processes. The sensitivity of 10-day forecasts to the initial state has been clearly demonstrated, emphasising, in particular, the crucial roles of data availability and quality control.

The analysis of humidity was reintroduced in operations in March 1981. In the 12 months prior to that time the humidity field of the model's initial state was simply that produced by the preceding 6 hr forecast, i.e. the first guess field. The overall impact on the quality of the ensuing forecast is small, possibly because the benefit of the humidity analysis is offset by the necessity for vertical interpolations to and from the model σ-levels.

Following an analysis of mass, wind and humidity on pressure levels, a vertical interpolation to the model's σ-levels is required. This is done by 'interpolation of increments', whereby only the increments of the analysis (i.e. differences between first guess and analysis) are vertically interpolated. The benefits of such a procedure were discussed in the previous annual report and the scheme has been successfully used in operations throughout 1981.

As the observational network in the Southern Hemisphere is notably sparser than that in the Northern Hemisphere, subjectively derived estimates ('PAOBS') of surface pressure are produced routinely at the WMC, Melbourne to augment the conventional data available to an objective analysis. These are available via the GTS at the Centre, and have been used operationally since March. They have a positive impact on both analyses and forecasts in the Southern Hemisphere.

Within the assimilation scheme there are a great many parameters which require specification. These are not known with certainty and their values are usually chosen to give reasonable analyses over a large range of cases. The forecast may be very sensitive to the choice of these parameters, and it is therefore important to identify such sensitivity where it exists. The problem of data checking within the analysis highlights the sensitivity. Because it involves a discrete judgement on the validity of a datum, its role in the analysis is often crucial. Whilst it is certainly possible to improve the data checking algorithms, through revision of the parameters and through general improvements in the data assimilation scheme, the nature of the problem will not be changed without a major improvement in the observing network. Figure 9 shows the difference at 500 mb of two 10-day forecasts, each starting from analyses for 12Z, 7 August 1980. The two analyses differed only in their treatment of one reporting platform, a ship at 20N 140E. One analysis used the ship's surface pressure datum from its surface report, the other took the corresponding (but different) information from the ship's upper air report. Substantial differences are evident in the two forecasts.

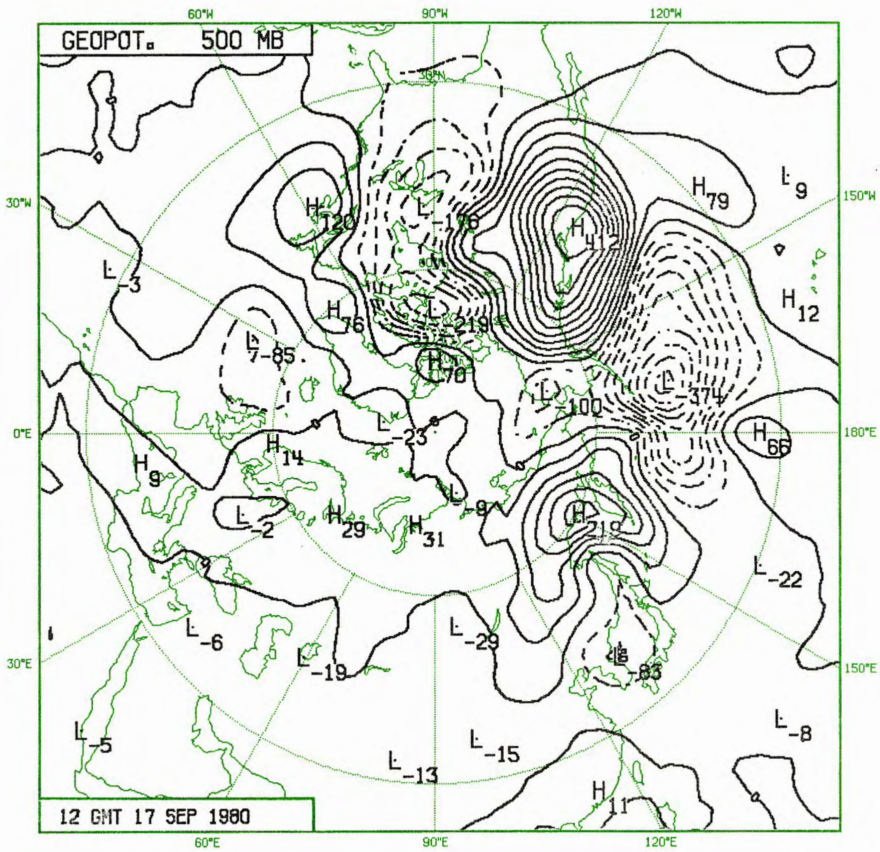


Fig. 9 Northern Hemisphere 500 mb height difference between two 10 day forecasts each starting from analyses differed only in the treatment of a single observing platform. Units: metres; contour interval 40 m.

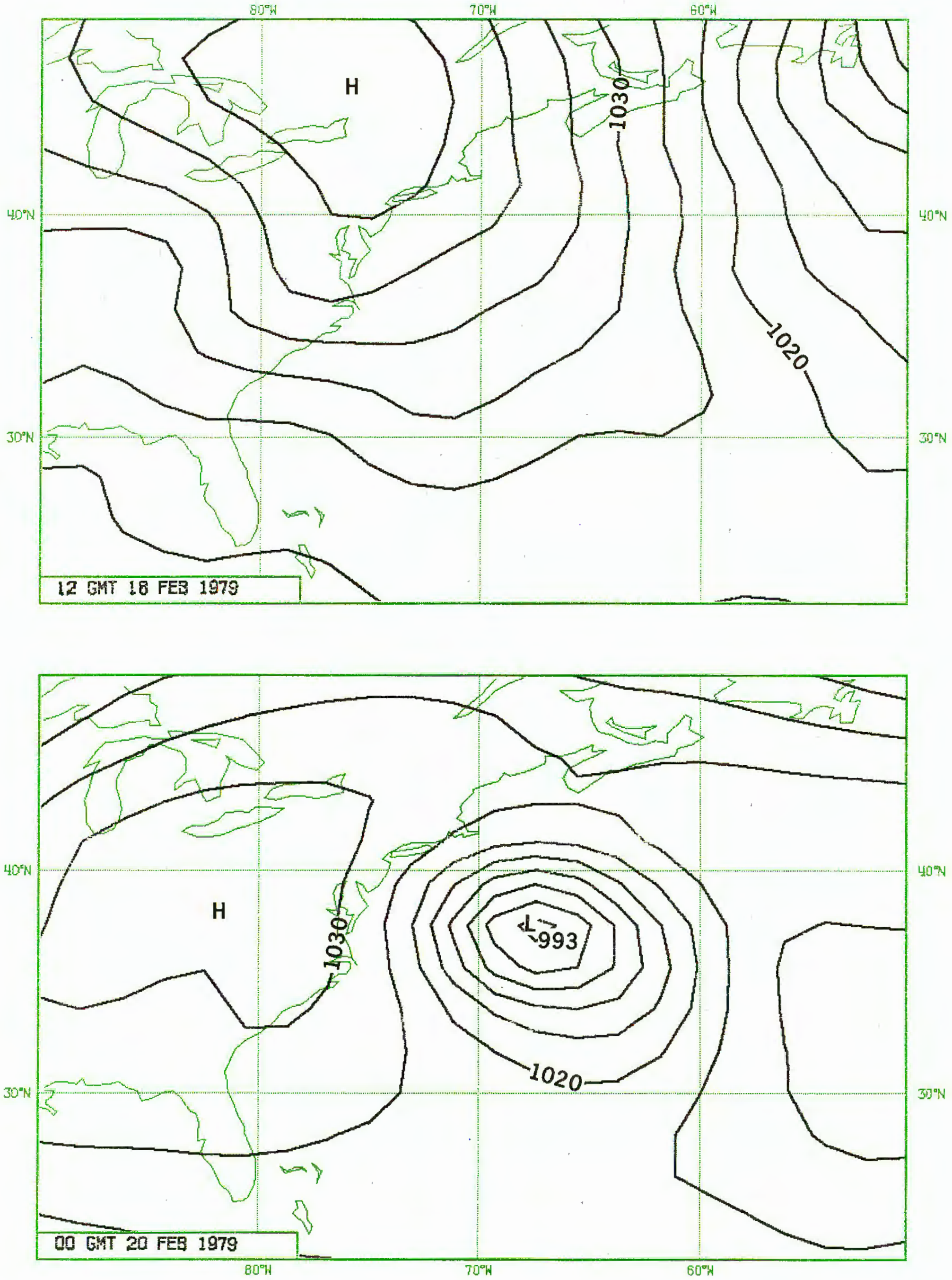


Fig. 10 Analyses of mean sea-level pressure (contour interval 5 mb) in the vicinity of the East coast of the USA for 12 GMT 18 February 1979 (top) and for 00 GMT 20 February 1979 (bottom).

Numerical Modelling

Substantial experimentation has shown that the T63 spectral model performs better than the N48 grid-point model and substantially better than the spectral model with a T40 resolution. During the year a small number of case studies were carried out in order to consider the effect of further increases in the model's resolution.

One series of experiments involved the comparison of 3 hemispheric spectral models at resolutions T40, T63 and T96, the latter being close to the highest truncation possible with the current organisation of the computer programs. One of the cases chosen for this particular series is one of intense cyclogenesis in the early stages of the forecast. Figure 10 shows mean sea level pressure maps for 12 GMT, 18 February 1979 (the initial data for the forecasts) and for 00 GMT, analyses. Between these times an intense development occurred near the eastern coast of the USA and the weather associated with it gave blizzard conditions over this region. Figure 11 shows the deepening of the low pressure centre in the (uninitialized) analyses and in the hemispheric T40, T63 and T96 forecasts. The T63 and T96 forecasts improve substantially over T40, and the T96 is clearly better than T63 in both the initial deepening and in the interruption of growth 36 hours into the forecast. Towards the end of the 3-day forecast period, however, T96 overdevelops the disturbance. When the new forecasting system (see below) is ready for research, it will be possible to carry out many more carefully controlled resolution studies.

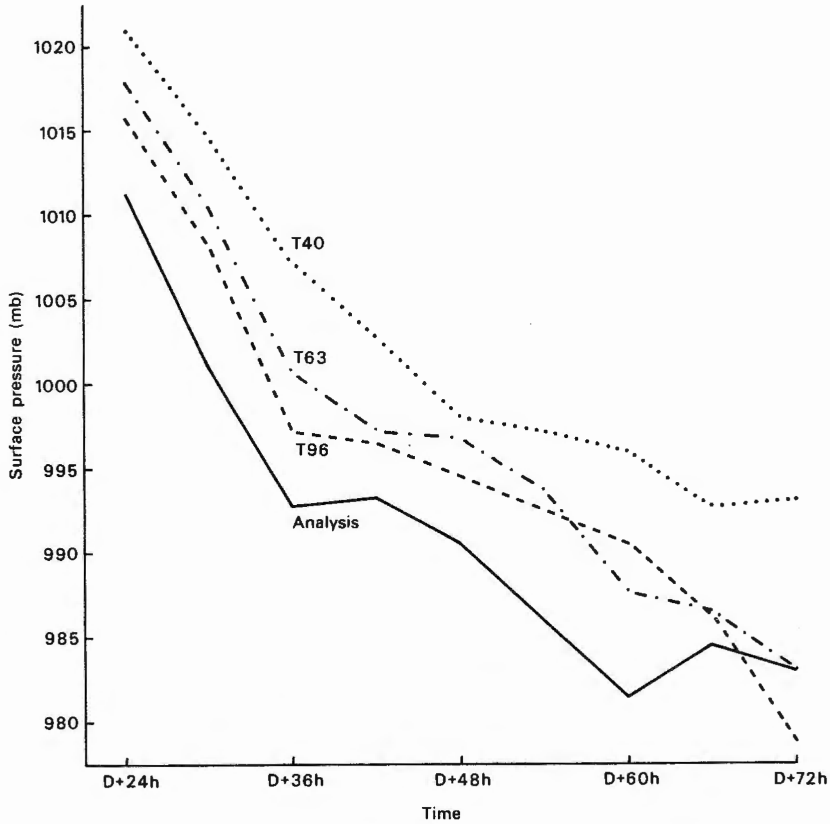


Fig. 11 The variation in time of the surface pressure minimum associated with the rapid cyclogenesis near the eastern coast of USA.

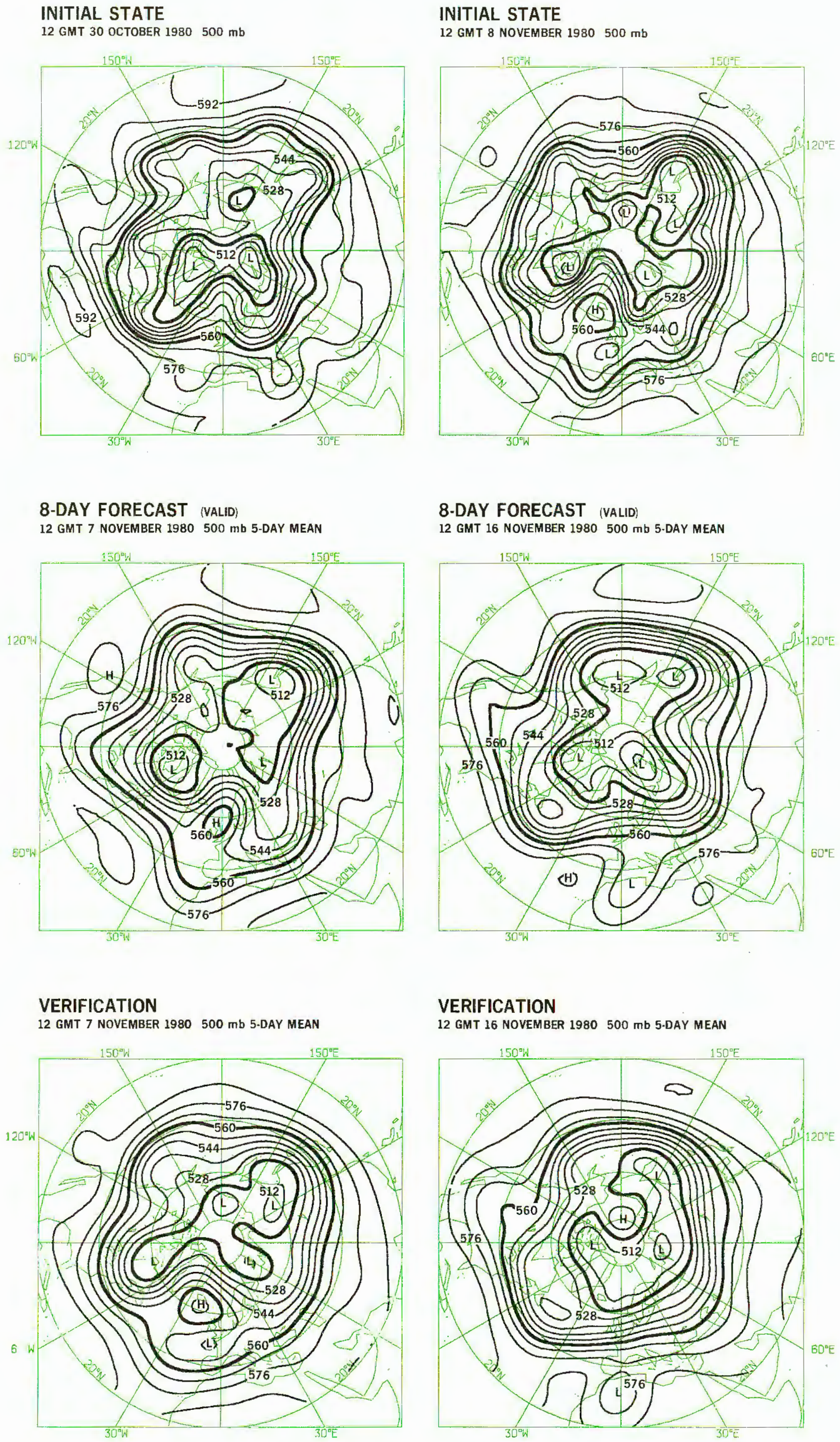


Fig. 12 Examples of two medium range predictions of the 500 mb flow. The forecast on the left indicates a prediction of a block, whereas that on the right forecasts the breakdown of that block. Isolines are every 80 m.

Forecasts of Five Day Means

It is particularly important to investigate the performance of our forecasting models when there are large scale changes in the circulation type. On many occasions such large changes are connected with atmospheric blocking. Figure 12 shows the successful prediction over a period of 8 days of a European block and the equally successful 8-day prediction of the breakdown of the same block. In order to exclude small scale errors, the forecasts as well as the "initial conditions" and "verification" are illustrated by five day means.

A New Orography, Coastlines and Surface Field Climatologies

The production of a more realistic orography and associated climatological surface fields, and the assessment of their impact on medium range weather forecasts have been a major undertaking for the Research Department since 1979. The fields that have been produced are:

	Main data sources
Surface geopotential	US Navy data
Land/sea indicator	US Navy data
Roughness length	US Navy data and Munich University (data on vegetation)
Albedo (annual climatology)	Nimbus 3
Surface temperature (monthly climatology)	NCAR and RAND climatologies
Soil water content (monthly climatology)	Climatological rainfall and temperature
Snowcover (monthly climatology)	Climate data.

The US Navy data have a latitude/longitude resolution of 10'.

After the introduction of these new surface fields, the N48 grid point model predicted, frequently, highly unrealistic rainfall patterns and amounts near steep orography. This problem has now been largely overcome.

As a result of the introduction of new surface fields, the quality of rainfall forecasts, particularly in the Alpine region, has been enhanced considerably. Elsewhere the improvement is even more impressive. Figure 13 shows total rainfall amounts for South America and Africa from 50-day simulations representative of both summer and winter. The delineation of the Atacama desert in South America is remarkable, as is the rainfall shadow over Madagascar in summer. Over Africa the

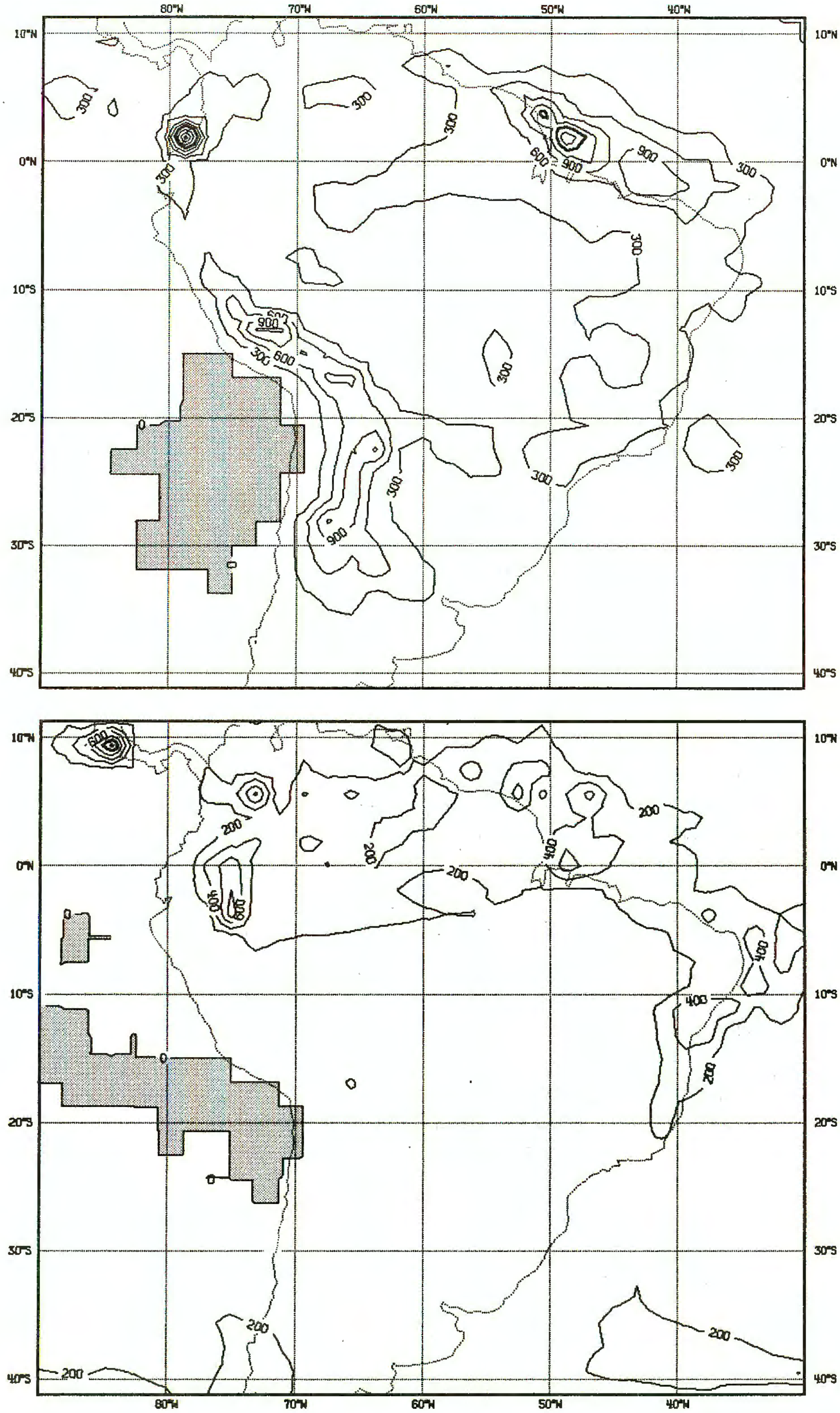


Fig. 13a Forecast 50 day rainfall total (mean) over South America for 21 January - 12 March (top) and 11 June - 31 July (bottom). Areas of no rainfall are stippled.

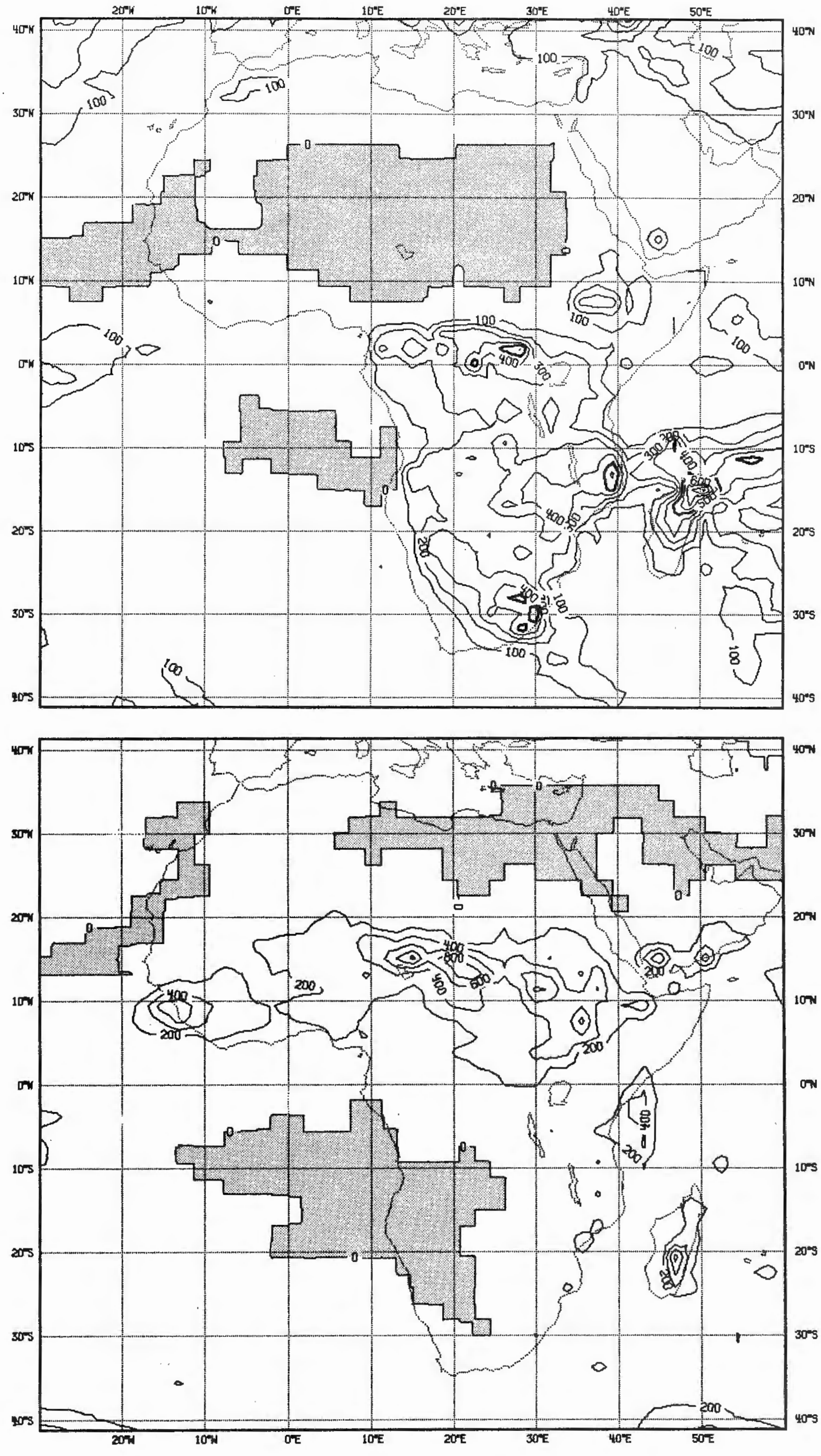


Fig. 13b As for Fig. 13a but for Africa.

areas of intense precipitation are well simulated in both winter and summer, though the summer rainbelt in Central Africa has been shifted a little more than 5° north of its true position.

Dynamical Studies

Although the major thrust of the Centre's research has been directed towards the immediate improvement of the forecasting system and the development of new techniques, some investigations of a more theoretical nature have also been carried out. The objectives of these studies have been an improved understanding of the response of the atmosphere to tropical forcing, and an assessment of a possible mechanism for blocking.

The forcing of stationary wave motion by tropical diabatic heating has been examined using idealised models. Steady solutions of a simplified version of the operational forecast model have been used to investigate both the extratropical and the tropical response. In the former case, isolated regions of tropical heating may excite wavetrains with a substantial poleward direction of propagation. These wavetrains resemble observed atmospheric teleconnection patterns. The tropical response is sensitive to the vertical distributions of the diabatic heating and static stability. Specific calculations have been used to aid understanding of some systematic deficiencies of the operational forecasts of quasi-steady tropical circulations.

Experiments have been performed with a barotropic model in which forcing is applied over isolated regions to a basic flow for which a climatological zonal variation is maintained by a separate steady forcing. In these cases, the largest response is found in those regions of the North Pacific and Atlantic where the observed variability of the mid-latitude flow is largest. This response can be substantially larger than found for a zonally uniform basic state. This suggests that numerical models with a too-zonal mean flow may underestimate sensitivity to anomalous forcing.

To obtain a more quantitative indication of the impact of the tropics on middle and high latitudes, a series of forecast experiments has been performed in which standard forecasts are compared with forecasts in which the tropics are forced towards their analysed state by a relaxation scheme. The impact on the extratropics varies from case to case, but a significant influence may be found on occasions. For example a marked improvement in a 6-day forecast over Europe may be traced back to underestimation of an upper-tropospheric anticyclone over the Caribbean during the first three days of the standard forecast.

A combined analytical/numerical study has been undertaken to investigate the nonlinear effects of orography on barotropic flow. In a low order model with spherical geometry, it has been found that a combination of orographic and zonally-varying momentum forcing can produce more than one equilibrium state for realistic parameter values. One of the stable states can be associated with a blocked flow pattern, while another has a much more pronounced zonal flow. Because of the nonlinearity of the governing equations, these stable equilibria exist for the same forcing.

The above results from a low order model have been verified with a high resolution barotropic model. In addition some diagnostic studies of blocking events during the FGGE year have suggested that the mechanism indicated by the theoretical study can be found in the atmosphere.

Convection

Assessment of extended integrations with the Centre's grid point model revealed several systematic deficiencies (see Annual Report 1980). Amongst those a substantial cooling and drying of the low- and mid-latitudinal mid-troposphere and an underestimate of the Hadley circulation and of the tropical rainfall were noticed. As these deficiencies are caused by insufficient diabatic forcing, particularly that arising from convection, a concentrated effort was made in 1981 to improve the parameterization of cumulus convection. Several convection schemes have been developed and are now available for numerical experimentation.

After extensive tests with GATE data using single column models, the Arakawa-Schubert scheme was tested in a global model and compared with the operational scheme (Kuo). Extended integrations with the global N48 grid-point model showed that the replacement of the Kuo scheme by the Arakawa-Schubert scheme leads to large differences in the tropical flow, especially in the upper troposphere.

Although the reason for these differences is not entirely clear at present, it is likely to be due to the different closure assumptions of the two schemes. Kuo's scheme is a moisture convergence scheme which probably favours convection forced by large-scale flow; whereas the Arakawa-Schubert scheme is a generalized moist-adiabatic adjustment scheme which emphasises convection by thermal forcing, as observed over the tropical continents.

The development of a new convection scheme in collaboration with Dr. M. Miller and Dr. M. Moncrieff from Imperial College, London, was initiated in 1980 and continued throughout the year. The scheme is based on extensions to theories proposed by Eady (1949) applied to cumulus convection. Steady state solutions of a displacement equation for cloud air are obtained for different kinds of environmental flow.

These are:

1) Symmetric flow for an environment with no windshear (the classical model);

2) Asymmetric flow due to vertical windshear (tropical model) describing a moving squall line with vertical transport of momentum.

The introduction of this cloud model into a large-scale model proved to be difficult with regard to the specification of a closure assumption which is still under discussion. So far, only the classical model has been introduced and tested in our global forecast model; 10-day integrations indicate that this scheme produces similar results as the Kuo scheme.

Following and extending a proposal by Lindzen, a further convection scheme was designed. In principle, this scheme is similar to Kuo's scheme, as moisture convergence is used for the closure; but the interaction between the convection and the large scale flow is similar to that formulated for the Arakawa-Schubert scheme. The scheme has been implemented successfully into the global model and preliminary results are promising, in particular the vertical distribution of convective heating and moistening being an improvement over that obtained with the Kuo scheme.

Planetary Boundary Layer

A new formulation of the vertical exchange coefficient for the turbulent fluxes has been prepared and tested. This was necessary as in the present formulation the sensible heat flux does not decrease as rapidly with increasing stability as is indicated by observational data. The revised formulation guarantees, for the stable case, smaller fluxes for sensible heat and moisture, and larger fluxes for momentum. It leads to some improvements in the model's temperature climatology in the lower troposphere.

Introduction of the Diurnal Cycle

At the present time the diurnal variation of solar radiation is not considered in the forecast model. Instead, the input of solar radiation is averaged over a whole day. Since the diurnal cycle is important for various reasons such as data assimilation, and more realistic thermal forcing over the continents, the radiation scheme has been modified to include the daily variation of the radiative fluxes. In order to save computing time, a technique of time and space interpolation of the radiative fields has been devised. In addition, the surface parameters appropriate for this diurnal cycle have been chosen after extensive testing with a one-column version of the operational model. A comparison between forecasts with and without the diurnal cycle shows an increase of the surface flux of sensible heat over the continents, together with a reduction of the evaporation. This change is most pronounced in mid-latitudes and is an improvement over the present model. These tests with the global model have also shown a fairly good representation of the temperature changes during the day, and of the daily pressure variation in the tropics. An example of these variations, compared with observations, is shown in Figure 14.

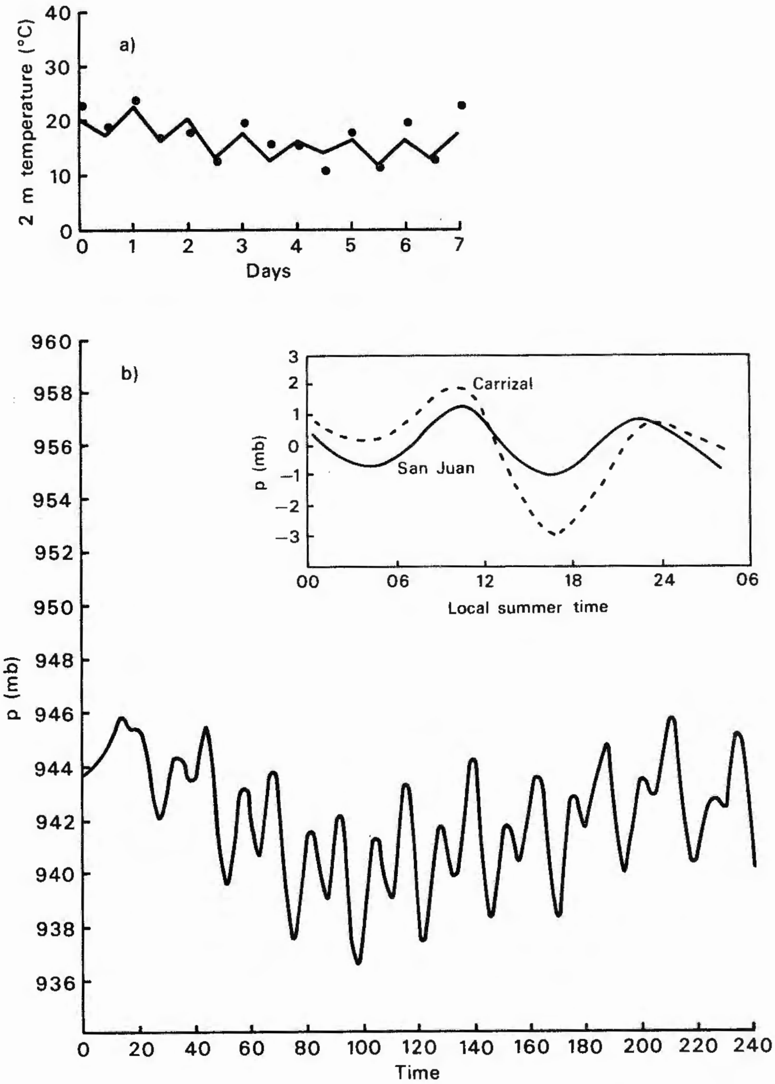


Fig. 14 Forecasts with a diurnal cycle.

a) Comparison of the forecast and observed temperature (dots) at 2 m in Bordeaux. The initial data time is 12 GMT 11 June 1976.

b) Comparison of the forecast diurnal variation of pressure in the tropics, 15°N and the average variation at two stations (inset).

A New Forecasting System

The development and subsequent evaluation of a spectral representation for the horizontal discretization has shown that spectral models perform better than grid point models for approximately the same cost; this has certainly been the Centre's experience with the T63 (triangular truncation at total wavenumber 63) spectral model and the operational N48 grid point model. A variety of terrain-following vertical co-ordinate systems have been developed and tested in the N48 global grid point model. The most successful and appropriate for forecasting and data assimilation are those in which there is a smooth transition from a sigma-like system near the earth's surface to a pressure co-ordinate in the lower stratosphere.

In order to implement these improvements into the operational system the Research Department started, in the latter part of 1981, to plan and design a new forecasting system based on a spectral model utilising a hybrid vertical co-ordinate system. The first version of this system, which will use the present parameterization scheme, will replace the present operational model late in 1982. The new design will give considerably more flexibility for research, allowing very high resolution experiments to be carried out, and facilitating the testing of alternative parameterizations which require extra prognostic variability and the introduction of finite element techniques for the vertical discretisation. Important components in the structure of the forecasting system are the post-processing and analysis interface since they will provide the means whereby forecasts can be made with various types of models - spectral, finite element, grid point - using data supplied by the analysis programs of a data assimilation procedure.

Diagnostic Studies

Much of the Research Department's diagnostic work has been concentrated on the investigation and documentation of the systematic errors of the forecast model.

Verifications of the tropical circulation in the forecasts show a rapid weakening of the trade winds at 850 mb, though the simulation at the 1000 mb level is better. Monthly mean maps of precipitation are reasonable both in amount and geographical distribution through the 10 day forecast period. The short-range predictions closely resemble the observed distributions while the 10 day forecasts tend towards climatology.

A frequency-wavenumber analysis has been performed in order to investigate the systematic error of the transient waves in the model. Comparison of analysed and forecast fields of geopotential height, temperature and wind indicates that the slowly moving, westward, planetary waves are predicted to be too intense while the synoptic, eastward moving waves are generally predicted to be too weak.

This becomes evident within the first three days of the forecast. Budget calculations of zonal mean momentum show that the shift of the subtropical jet is due to an increase of the meridional eddy flux of momentum. The reason for this is a subject for further investigation.

Budget calculations of humidity, temperature, kinetic energy and available potential energy allow an estimation of subgrid-scale, diabatic, processes. These are calculated for the whole globe and for limited areas. From these it is evident that the analysed data have reached a quality which can exhibit a diurnal cycle in the divergent wind component, the amplitude of which is about 20 cm/sec over Europe. The calculations also reveal that maxima of dissipation of kinetic energy near the jet levels are less sharp in the forecasts and that the diabatic heating in the lower troposphere over the oceans is too small.

Energy Cycles Derived From Observed and Forecast Data

When Lorenz introduced the energy cycle diagram in 1956 it was quickly adopted as a very useful concept. Figure 15 shows the annual mean energy cycle for the global atmosphere comparing analysed and forecast data for days 1,5 and 10. The terms representing subgrid-scale processes, i.e. the generation of eddy available potential energy and the dissipation of kinetic energy have been calculated as residuals from the other terms. An overall increase in conversion rates of the order of 50% during the course of the forecast can be seen. The energy densities, however, increase by less than 10% (or even decrease, as found for the eddy kinetic energy). This suggests that the model atmosphere becomes more efficient in converting energy; for example, the troughs and ridges are more tilted in the forecasts. The reasons underlying this increase in the thermodynamic efficiency of the model atmosphere compared to the real atmosphere are the subject of continuing study.

FGGE Analyses

The assimilation of the FGGE year observations, the most complete set of global observations ever assembled, into a set of global analyses was finalised in the summer of 1981. This so-called FGGE level III-b dataset covers the period 1 December 1978 to 30 November 1979 with global analyses four times per day. The data set has been archived at the two World Data Centres for Meteorology in Asheville, USA and Obninsk, USSR. It is also available directly at ECMWF.

The ECMWF level III-b data are already extensively used by the scientific community, both within the Member States and worldwide. The dataset is also used heavily internally for development work, both of analysis and forecast models.

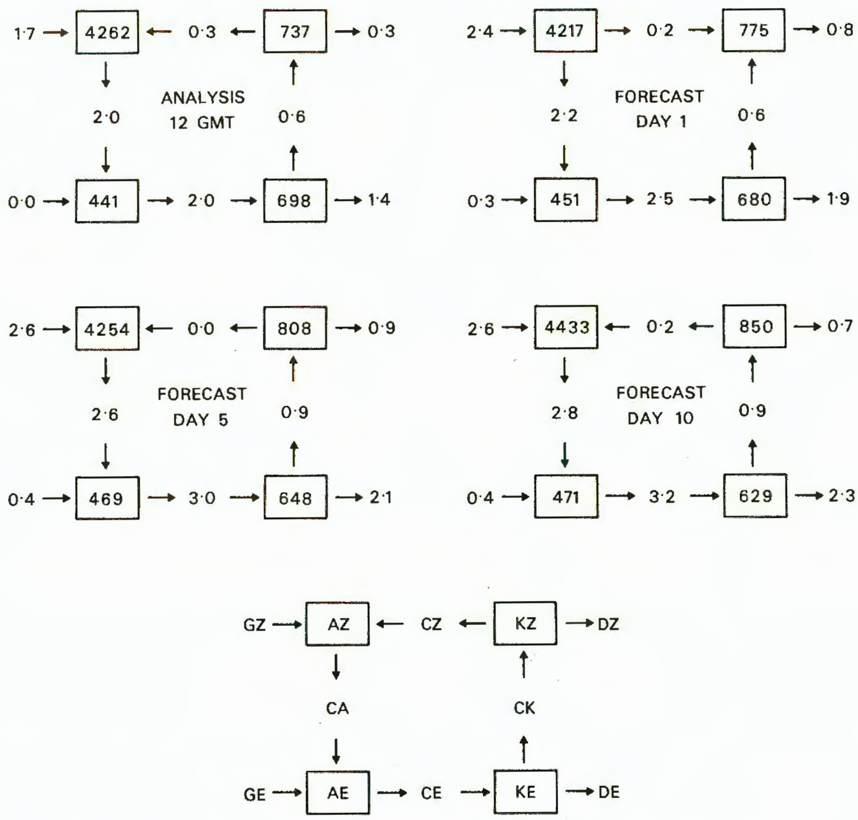


Fig. 15 Energy cycle for the global atmosphere (1000-30 mb) for the period August 1980 - July 1981. Units: conversions in Watt/m^2; energy contents in kJ/m^2.

The FGGE dataset has made possible for the first time detailed synoptic analyses of phenomena in areas normally almost void of observations. Present knowledge about the circulation over many areas, particularly the Indian and Antarctic Oceans, will be considerably modified when the full scientific evaluation of the FGGE data has been made.

A major focus of interest during FGGE was the onset of the Asian summer monsoon. Figure 16 shows the 850 mb wind analyses over the Indian Ocean and adjacent areas on June 11 and June 15 respectively. The large scale of the monsoon onset is striking. Complete reversal of the circulation south of Madagascar between the two analyses can be seen. This reversal is closely related to the penetration of the Arabian Sea monsoon towards the Indian subcontinent. An interesting detail is the cyclonic vortex that develops over the eastern Arabian Sea at the onset of the monsoon.

The programme of Observing System Experiments co-ordinated by the European Working Group on a Future Observation System continued during 1981, in cooperation with visiting scientists from the Member States. A major experiment aiming to

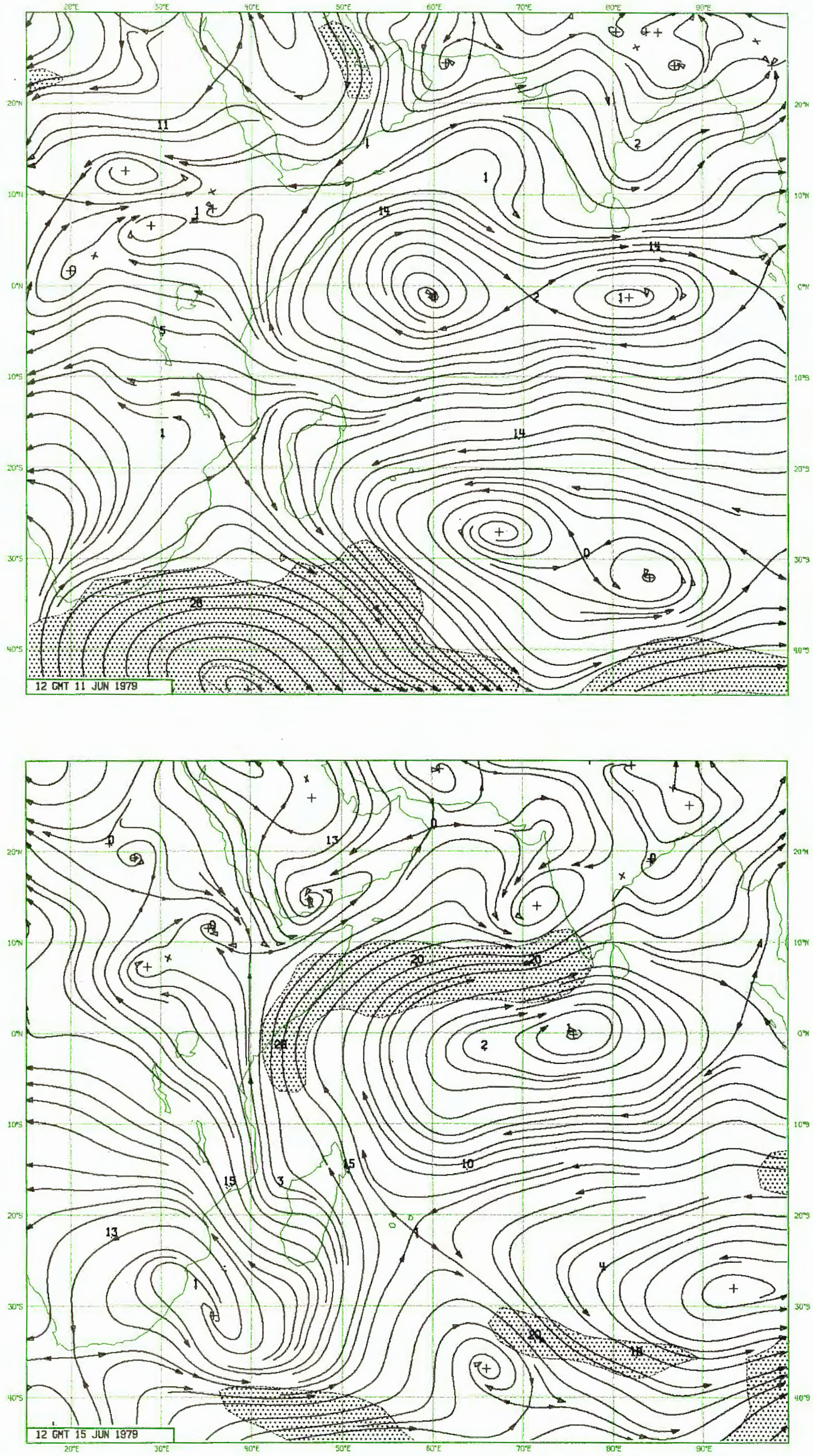


Fig. 16 850 mb wind analysis at 12 GMT on 11 and 15 June 1979 just before and after the onset of the Asian summer monsoon. Full lines are streamlines and dashed lines isotachs. Areas with windspeeds above 15 ms^{-1} are stippled.

evaluate the impact of cloud drift wind data from geostationary satellites on tropical analyses as well as medium range forecasts at middle and high latitudes was finalised. The results indicate a clear improvement both on tropical wind analyses and on southern hemisphere forecasts. In the northern hemisphere the cloud wind data also improves the forecasts, although the improvement is less than that found in the southern hemisphere.

Consultants and Visiting Scientists

During 1981, the Research Department employed the following consultants, visiting scientists, or experts:

Mr. K. Bjørheim	Meteorological Institute Oslo, Norway
Dr. W. Bourke	Australian Numerical Meteorological Research Centre Melbourne, Victoria, Australia
Dr. C. Girard	Atmospheric Environment, Montreal, Canada
Mr. N. Gustafsson	Swedish Meteorological and Hydrological Institute Norrköping, Sweden
Dr. Ji, Li-ren	Institute of Atmospheric Physics Peking, China
Dr. K. Johannessen	National Weather Service Silver Spring, Maryland, USA
Dr. M. Kanamitsu	Electronic Computing Center Japan Meteorological Agency Tokyo, Japan
Professor E. Lorenz	Massachusetts Institute of Technology Cambridge, Massachusetts, USA
Dr. B. Lykossov	Computing Centre Akademgorodók, Novosibirsk, USSR
Dr. M. Miller	Imperial College of Science and Technology London, United Kingdom
Dr. M. Moncrieff	Imperial College of Science and Technology London, United Kingdom
Mr. J. Pailleux	SMM/PREVI/DEV Météorologie Nationale Paris, France
Dr. J.M. Wallace	University of Washington Seattle, Washington, USA

Administration Department

The revised organization plan of the Administration Department was shown in the previous year's Annual Report. With the arrival of Mr. D.J. Goossen, Head of Personnel and General Services, in April 1981, the last element of the reorganization was complete.

During the year, improvements to personnel procedures were introduced and the preparation of the implementation instructions to the Staff Regulations was undertaken. A decision on the computerization of the accounting records was made during the year 1981. Studies for the implementation of this decision have also been made and a consultant selected. It is hoped that the new computerised system will be implemented during the next year. More favourable banking facilities were negotiated with the Centre's bankers.

The Centre liaised with the working group on Eumetsat, on which a final decision has not yet been taken, and the Administration Department established costings on personnel and support facilities.

Financial Management

A review of the past six years budgetary estimates shows that these, and in turn associated annual surpluses, have been managed in a much stricter manner. Figure 17 shows the decrease in the budgetary surplus over the years 1976-81.

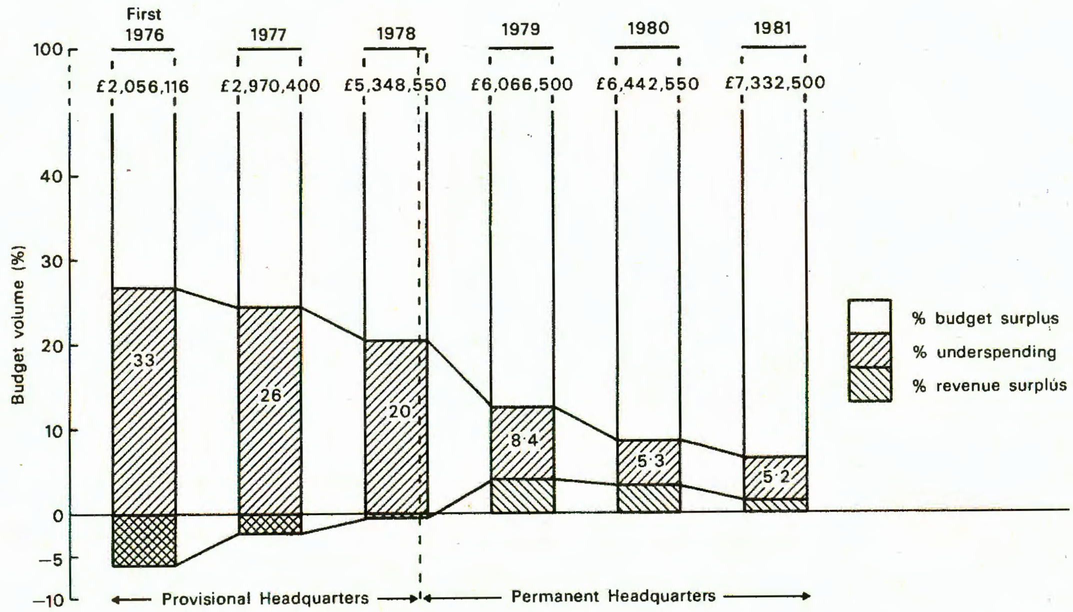


Fig. 17 Percentage budgetary surplus and underspending for the first six financial years 1976-1981.

The Centre's auditors have acknowledged this fact and considered the 1980 annual surplus to be acceptable.

Purchasing Power

Although the retail price index has risen some 29% over the years 1979 - 81, the Centre's budget has only increased by some 20%. The effect of the increase in prices with respect to use of two of the main services to the Centre - electricity and telephone - can be seen from Figures 18 and 19 respectively. From these it can be seen that consumption has remained reasonably constant, whereas total costs have increased considerably.

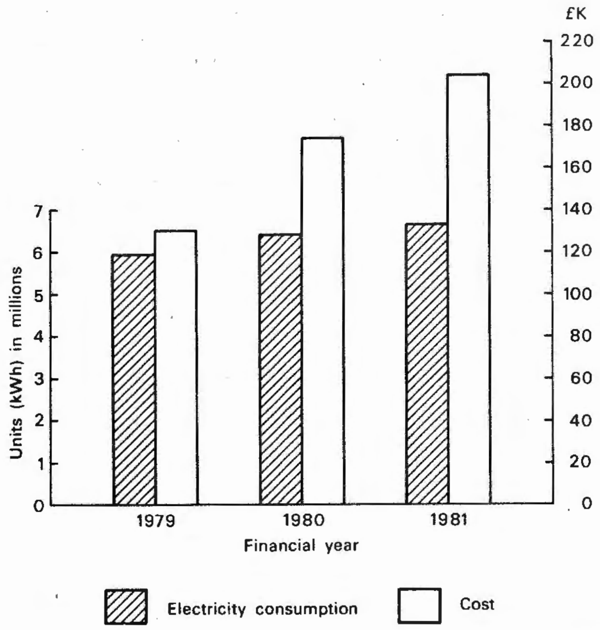


Fig. 18 Electricity consumption and cost 1979-1981.

Budget

The Centre's Budget 1981 was adopted by the Council at its 12th session held on 20 - 21 November 1980. The approved total revenue and expenditure for the year 1981 was £7,332,500 - an increase of £889,950 (13.81%) over the Budget 1980. The increase was due mainly to salary adjustments and higher operating expenditure. The 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 20 shows the total expenditure during the years 1976 to 1981 for staff, computer costs, and other expenditure.

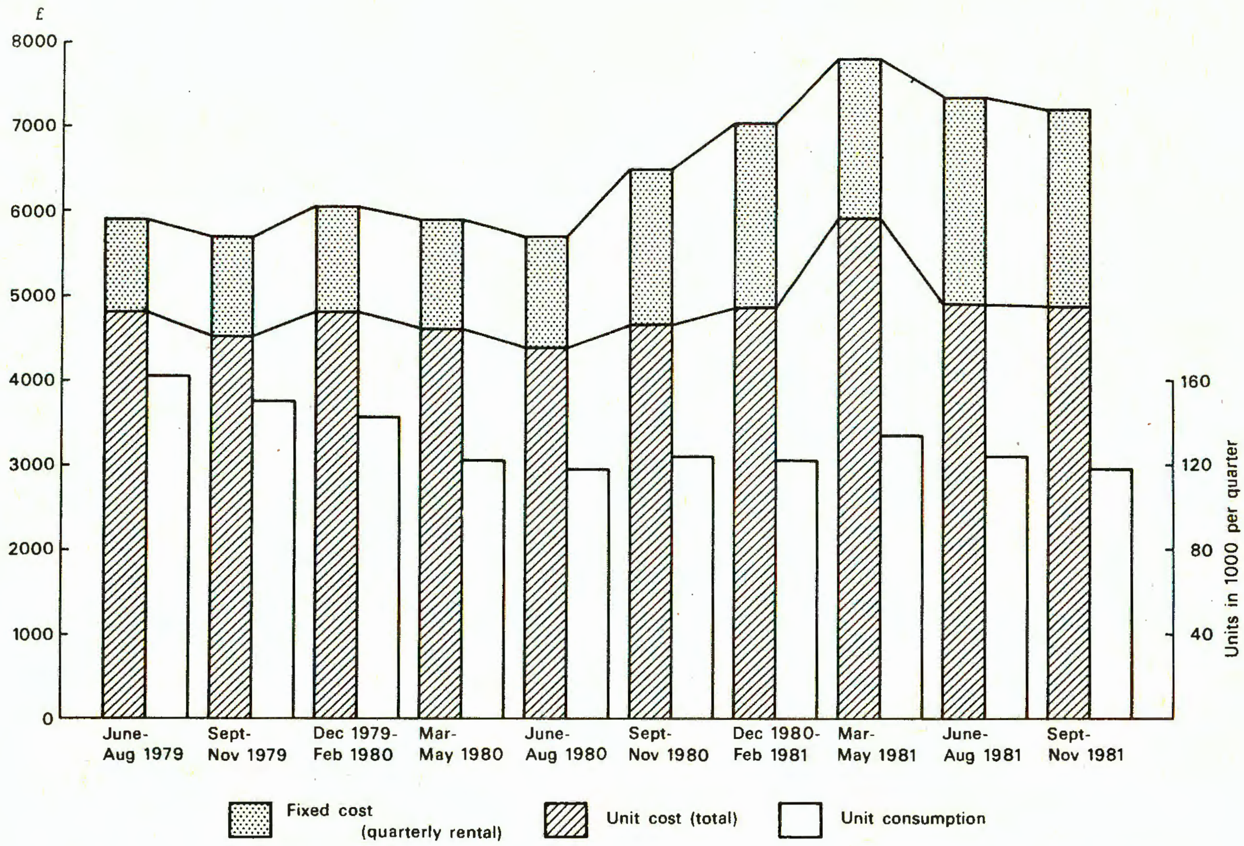
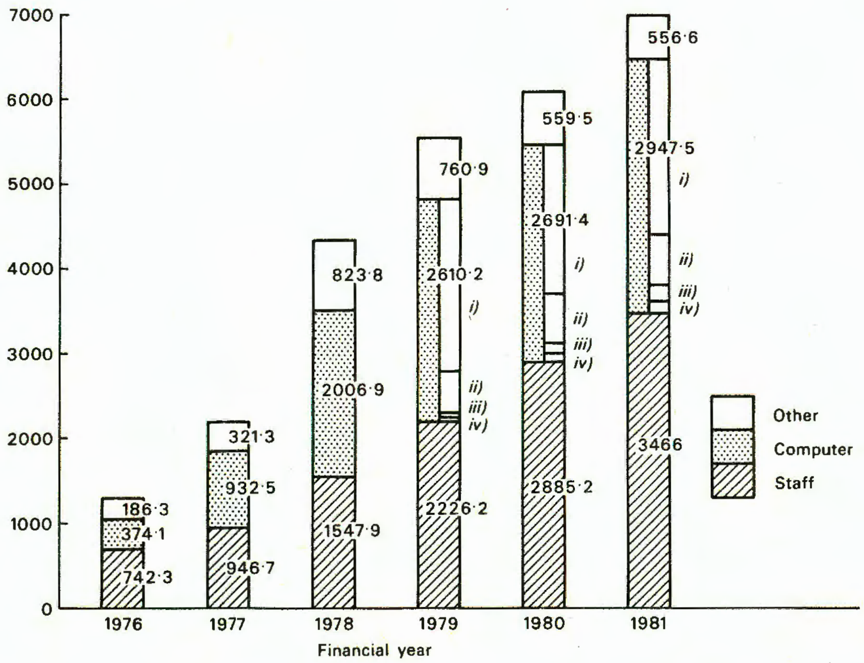


Fig. 19 Quarterly telephone (main line) cost and unit consumption 1979-1981.

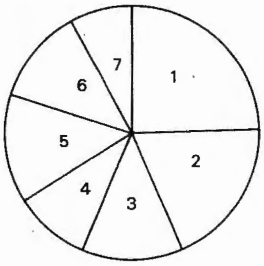


Note: Figures revised for 1979-80 to include certain 'computer' expenditure previously included in 'other'. Computer expenditure further apportioned as i) hiring/leasing/investment ii) maintenance iii) telecommunications iv) misc..

Fig. 20 Expenditure on staff, computer operations and other items during 1976-1981.

Scale of Contributions

The estimated Member States' contributions towards the 1981 Budget amounted to £6,212,300. These contributions were to be paid according to the Scale of Financial Contributions of the 17 Member States, calculated on the basis of the Gross National Product (GNP) expressed in dollars, of each of the Member States for the years 1974, 1975 and 1976. Figure 21 shows the geographical distribution of Member States' contributions during the period 1979 to 1981, together with a table showing the actual percentages.



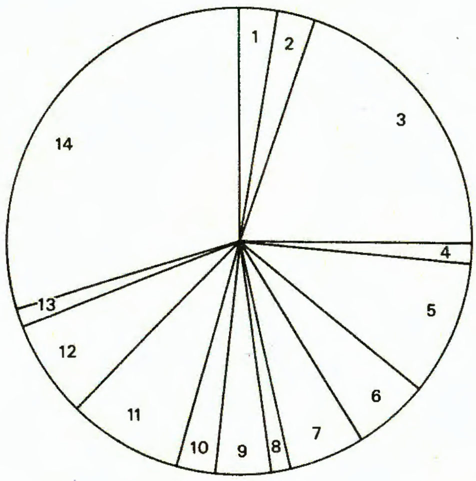
CODE	COUNTRY	% CONTRIBUTION	
1	Germany		24·64
2	France		18·77
3	U.K.		12·74
4	Italy		9·86
5	The Netherlands	4·80	13·91
	Belgium	3·68	
	Switzerland	3·23	
	Austria	2·20	
6	Spain	5·82	12·16
	Turkey	2·15	
	Yugoslavia	2·06	
	Greece	1·26	
	Portugal	0·87	
7	Sweden	3·93	7·92
	Denmark	2·04	
	Finland	1·50	
	Ireland	0·45	

Fig. 21 Geographical and percentage distribution of Member States' contributions for 1979-1981.

Staffing

As at 31 December 1981, the table of staff was for 143 posts; of these 136 posts were filled, leaving 7 posts vacant. Further, there were 9 visiting scientists/consultants working at the Centre. During the year the Centre continued with its efforts to improve the balance of the geographical distribution of its staff. By the end of the year, nationals from 15 Member States were present on the Centre's staff as compared to 14 in 1980. Figure 22, and the following Table 4, show the 1981 geographic distribution of A and L grade staff members. Recruitment of computer staff was accomplished by advertising in major national newspapers of Member States, we well as announcing the vacancies to the national meteorological services, universities and computer centres in the Member States. These efforts proved worthwhile; in several instances 60 - 90 applications were received for each post. In total, some 600 applications were dealt with during the year. However, for some vacancies in the field of meteorology very few applications were received.

The eight vacant posts existing at the end of 1980 were filled during 1981, four internally and four externally. Eleven staff members left in the course of 1981. One post was suppressed and of the ten vacancies remaining, five were filled internally and five externally. Of the total of fifteen vacancies, nine were in the Operations Department, four in Research, and two in Administration.



	%
1 Belgium	2·67
2 Denmark	2·67
3 Germany	20·00
4 Spain	1·33
5 France	9·33
6 Ireland	5·33
7 Italy	5·33
8 Yugoslavia	1·33
9 The Netherlands	4·00
10 Austria	2·67
11 Finland	8·00
12 Sweden	6·67
13 Turkey	1·33
14 U.K.	29·34

Fig. 22 Geographical and percentage distribution of A and L grade staff at 31 December 1981.

Co-Ordinated Organisations

The Centre has still not been admitted to the Co-ordinated Organisations. Discussions with the Secretaries General and the national delegations are continuing. The Co-ordinating Committee of Government Budget Experts (CCG) has presented another report to the Councils of the Co-ordinated Organisations recommending once again the admission of ECMWF and the European Patent Office (EPO) to these Organisations.

European School

For the first time, some ECMWF staff members had problems in enrolling their children since in several classes of different language sections the number of children is reaching a maximum. In the end, but probably for the last time, a solution was found. In the course of this year, the Centre started formal negotiations with the European Schools to ensure admission to the School in future and

Table 4 Staff at 31 December 1981

Director	J. Labrousse	France
Deputy Director/ Head of Research Department	O.L. Bengtsson	Sweden
Head of Operations Department	J.D.K. Söderman	Finland
Head of Administration Department	H. Hartwig	Germany

Distribution of Staff by Category and States

Category / Country	*hg	A	B	C	L	TOTAL
Belgium		2				2
Denmark		2				2
Federal Republic of Germany		14	3		1	18
Spain		1				1
France	1	5	2		1	9
Greece						
Ireland		4	1			5
Italy		4	1			5
Yugoslavia		1	1			2
The Netherlands		3	4			7
Austria		2				2
Portugal						
Switzerland			1			1
Finland		6	1			7
Sweden		5				5
Turkey		1				1
United Kingdom		22	41	6		69
TOTALS	1	72	55	6	2	136

*Hors grade

avoid such problems. From the beginning of the 1981/82 school year in September 1981, responsibility for the transport of children of staff members attending the European School in Culham was undertaken by a newly-formed Parents' Committee. The Centre continued to provide the services of a driver, supervisor and one vehicle, but all additional transport required in the last term of 1981 to accommodate the additional children now going to the School was provided, administered and funded by all the parents concerned.

Social Security

The discussion on exemption from compulsory contributions to the UK Social Security Scheme for UK nationals ended with the conclusion of an Agreement, giving such exemption, between the Centre and the Government of the United Kingdom. The position of the Centre's staff with regard to the Social Security Schemes applicable in their home countries is being examined by the Administration Department. The Centre, for the most part, makes its own provisions for social security, such as old age, invalidity, widow's and orphan's pensions, pay during sickness and payment of dependents' allowances. During 1981 one widow's together with one orphan's pension was paid. On average, dependents' allowances were paid in respect of 150 children, and the number of man-days lost due to sickness and maternity leave amounted to 850 days, or 2.9% of the actual man-days available in 1981.

Security

As a result of the experience gained from the previous security arrangement, the Centre decided in November to implement a night-time security service in place of the existing day-time service.

Restaurant

The Centre reviewed the restaurant catering facilities during 1981 and subsequently issued an Invitation to Tender specifying a no-subsidy contract. Tender specifications were sent to a total of 28 potential contractors; only two replies offered the possibility of a no-subsidy contract and only one of these was considered to be a serious contender. It should be noted that the Centre's current catering contractor, who had been operating since the opening of the restaurant, did not tender for this contract. The Centre has now entered into a new contract which will commence on 1st January 1982.

Conferences, Seminars, Meetings, etc.

The Centre's Conference Block facilities were in regular use throughout the year. The total number of long meetings, conferences and seminars supported by General Services was 20. In addition numerous short lectures were given.

Education

Seminars

This year's annual seminar took place during the week 14 - 18 September and was entitled "Problems and prospects in long and medium range weather forecasting". Forty-two meteorologists from eleven Member States participated. The proceedings will be published in the spring of 1982.

The following scientists were invited to give lectures:

Dr. A. Gilchrist	UK Met Office, Bracknell, UK
Dr. C. Leith	National Centre for Atmospheric Research Boulder, Colorado, USA
Professor E. Lorenz	MIT, Cambridge Massachusetts, USA
Dr. R. Madden	National Centre for Atmospheric Research Boulder, Colorado, USA
Dr. J. Shukla	Goddard Laboratory for Atmospheric Sciences Greenbelt, Maryland, USA

The subjects covered were:

- Review of recent progress made in medium range weather forecasting
- Methods for long range forecasting
- Predictability of the atmosphere
- Diagnostic methods to investigate potential predictability
- Blocking theories

Another seminar, on "Graphical Applications in Meteorology" was held from 19 to 23 October 1981. Thirty-eight scientists attended from thirteen of the Member States, plus two main speakers, from the UK and the USA. The meeting served two purposes, in that it brought together meteorologists from Member States responsible for, or particularly involved in, graphics in order to review the present situation as far as graphical applications are concerned. Secondly it presented to participants the current situation in the field of graphics (hardware and software) and of future developments. The proceedings will appear in the spring of 1982.

Meteorological Training Course

The training course this year was divided into three separate parts:

A1	Basic dynamic meteorology	(5 May - 29 May)
A2	Theoretical aspects of the ECMWF forecasting system	(1 June - 12 June)
B	Operational asepcts of the ECMWF forecasting system	(15 June - 26 June)

In total, the course was attended by twenty meteorologists from ten Member States. The participants were generally pleased with the contents and the organization of the course. The literature used on the courses were the lecture notes published in 1979 by ECMWF, and Technical and Internal Reports.

Some of the course participants undertook a special project during the course, working in close collaboration with a Research Department staff member.

A two week section of the course, namely the part oriented towards the practical application of the Centre's forecasting system was arranged by the Operations Department, and included laboratory sessions, in which the Centre's operational data bases were used to display and make use of forecast results. Two days instruction on how to run simple jobs on the ECMWF computer system were also given.

Computer Training Courses

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

Introduction to the use of the ECMWF computer facility	16-20 March and 21-25 September
Advanced use of the Cray-1	23-27 March and 28 Sept - 2 Oct

The total number attending (often more than one of the courses) was thirty from ten Member States plus Iceland, and nine Centre staff.

Workshops

Four workshops were held in the course of the year. These were on the following subjects:

- Tropical meteorology and its effect on medium range prediction at middle latitudes. The workshop took place on 11-13 March, and the proceedings were published in December;

- Implementation of GKS at ECMWF (GKS is the draft proposed international standard in graphics). The workshop took place on 15 - 17 May, and the proceedings were published in September;

- Parameterisation of the planetary boundary layer in numerical models. The workshop took place on 25 - 27 November, and the proceedings will be published in the spring of 1982.

- High-bandwidth local networking. The workshop took place on 15 - 16 December.

Lectures

In addition to the above, a number of lectures on subjects related to the work of the Centre were given for ECMWF staff throughout the year.

The Council and its Committees

Council

The Council met twice during 1981, for its 13th and 14th sessions, held on 29-30 April and 19-20 November respectively.

The representatives of the Member States at these sessions were:

State	Delegate	Session
President (Germany)	Mr. Lingelbach	13 and 14
Belgium	Mr. Sneyers	13 and 14
	Mr. Deloz	13 and 14
Denmark	Mr. Asmussen	13 and 14
	Mr. Nielsen	13
	Mr. Mikkelsen	14
Germany	Mr. Schulze	13 and 14
	Mr. Mohr	13
Spain	Mr. Sanchez	13
	Mr. Orfila	14
France	Mr. Gosset	13 and 14
	Miss Martin-Sané	14
Greece	Mr. Bassiakos	13 and 14
Ireland	Mr. Linehan	13 and 14
Italy	Mr. Zancla	13 and 14
Yugoslavia	Mr. Vasic	14
The Netherlands	Mr. Bijvoet	13 and 14
	Mr. Voerman	13 and 14
Austria	Mr. Cehak	13 and 14
Portugal	Mr. Mendes-Victor	13 and 14
	Mr. Carvalho	13 and 14
Switzerland	Mr. Gutermann	13
	Mr. Simmen	14
Finland	Mr. Jatila	13 and 14
	Mr. Rinne	14
Sweden	Mr. Ag	13 and 14
	Mr. Sundelius	13 and 14

State	Delegate	Session
Turkey	Mr. Özgül	14
United Kingdom	Mr. Day	13 and 14
	Sir John Mason	14
WMO Observer	Mr. Schneider	13
	Mr. Wiin-Nielsen	14
Icelandic Observer	Mr. Sigtryggsson	14

At its 14th session the Council re-elected Professor Dr. E. Lingelbach (Germany) and Dr. L.A. Mendes-Victor (Portugal) for a second year as President and Vice-President respectively. Also during this session, a small ceremony took place to unveil the rolls of honour of past Presidents and Vice-Presidents of the Council, which, together with photographs of past Directors, now hang over the staircase leading to the Conference Suite.

Finance Committee

The Finance Committee met three times in the course of 1981, for its 24th, 25th and 26th sessions, held on 4-6 March, 15-17 July and 22-24 September respectively.

The sessions were held under the chairmanship of Mr.P.P. Wrany (Germany). Mr. M. Deloz (Belgium) was Vice-Chairman. The composition of the Finance Committee during 1981 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:

Belgium
Portugal
Sweden

At the 13th Council session it was noted that as from 21 November 1981 these three would be replaced by:

Spain
Austria
Finland

Their term of office will be for one year.

At its 26th session the Finance Committee elected Mr. G. Day (United Kingdom) as its Chairman for a term of one year from 21 November 1981. Election of a Vice-Chairman was postponed until the 27th session of the Committee.

Scientific Advisory Committee

The 9th session of the Scientific Advisory Committee took place on 21-22 May 1981.

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

Professor F. Mesinger	-	Chairman	Yugoslavia
Dr. C.J. Schuurmans	-	Vice-Chairman	The Netherlands
Dr. J.R. Bates			Ireland
Mr. F. Bushby			United Kingdom
Dr. E. Eliasen			Denmark
Dr. K. Hasselmann			Germany
Dr. B. Hoskins			United Kingdom
Professor J. van Isacker			Belgium
Professor J.P. Peixoto			Portugal
Dr. H. Reiser			Germany
Dr. R. Sadourny			France
Dr. H. Sundqvist			Sweden

At the 14th session of the Council in November 1981, Dr. Schuurmans was reappointed for a second term of four years, and the two other outgoing members, Dr. Eliasen and Dr.Hasselmann, were replaced by Dr. L. La Valle (Italy), and Dr. B. Machenhauer (Denmark), who were appointed for a first term of four years.

At its 9th session the Scientific Advisory Committee endorsed the basic strategy of the research programme in the four year period 1982 - 1985, the basic objective being to improve the quality of the forecasts, in particular in the time range beyond five days.

Technical Advisory Committee

The Technical Advisory Committee held its 3rd session on 9-12 June 1981.

All Member States are members of the Technical Advisory Committee. The representatives of each Member State in 1981 were:

Mr. J. Lepas (Chairman)	France
Mr. W. Wann (Vice-Chairman)	Ireland
Dr. W. Struylaert	Belgium
Mr. E. Busch	Denmark
Dr. W. Buschner	Germany
Mr. B. Orfila	Spain
Mr. G. Barbournakis	Greece
Dr. G. de Florio	Italy
Mr. Z. Butigan	Yugoslavia
Dr. A. Baede	Netherlands
Dr. G. Wihl	Austria
Mr. S. Cristina	Portugal
Mr. M. Haug	Switzerland
Mr. A. Lange	Finland
Dr. R. Berggren	Sweden
Director General	Turkey
Mr. D. Johnson	United Kingdom

The Committee, inter alia, reviewed the plans for the telecommunications networks between the Centre and the Member States and the allocation of computer resources to Member States and supported the Centre's plans for the period 1982-85, including the provision of extra computing resources.

Member State Computing Representatives Meeting

A successful second meeting was held from 14 to 16 October; representatives from twelve Member States attended. The meeting brought everyone up to date with computer activities over the past 12 months and with plans or changes for the next year, bothat the Centre and in each Member State where relevant to the Centre.

Forecasters Meeting

In the evaluation of the ECMWF forecasts, feedback from the users in the Member States is highly important, and is taken seriously into account. The opinions of experienced forecasters reflect the views of the first level of practical users of the forecasts. Accordingly, a meeting of forecasters was held before the third session of the Technical Advisory Committee and took place at ECMWF on 18-19 May 1981. Forecasters and experts with considerable synoptic experience who had studied the Centre's products, coming from twelve Member States, attended the meeting. Their conclusions were that:

(i) The Centre's products have become essential and integral parts of the routine operational medium-range forecasting in the majority of Member States, being used in applications such as ship routeing, marine and agricultural forecasting and general forecasting for the media and public;

(ii) There was evidence of improvement in the quality of the Centre's products since the first meeting of Forecasters;

(iii) The Centre's forecasts are as good or better than other numerical forecasts currently available operationally.

International Meetings and Visits

As in the past, 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, inter alia, at the following:

International Conference on early results of FGGE and large-scale aspects of its monsoon experiments, Tallahassee, Florida, USA (January)

Data base structure and access methods course, The Hague, The Netherlands (February)

NEPHOS meetings, France and UK (February, March, April, July, November)

Joint Scientific Committee meeting, Vienna, Austria (April)

ECODU-31, Helsinki, Finland (April) and
ECODU-32, Montreux, Switzerland (October)

COMNET, Budapest, Hungary (April)

CBC 18/20 MSS user group, Geneva, Switzerland (May)

International Conference on current problems of weather prediction Vienna, Austria (June)

IEE Seminar on Electrical Standards, Bristol, UK (June)

SFP Congress, Clermont-Ferrand, France (June)

XII Jornadas Meteorologicas, Santiago/da Couruna, Spain (June)

First British National Conference on Data Bases, Cambridge, UK (July)

IAMAP Symposium on the Dynamics of the General Circulation of the Atmosphere: Emphasis on the mid-latitude troposphere, Reading, UK (August)

IAMAP Third Scientific Assembly, Hamburg, Federal Republic of Germany (August)

Working Group on Numerical Experimentation, Stockholm, Sweden (August)

Conference on Vector and Parallel Processors in Computational Science, Chester, UK (August)

Symposium on Variation in the Global Water Budget, Oxford, UK (August)

International Conference on Performance of Data Communication Systems and Applications, Paris, France (September)

"Eurographics 81", Darmstadt, Federal Republic of Germany (September)

IV Asamblea Nacional de Geodesia y Geofisica, Zaragoza, Spain (September - October)

WMO EC Inter-Governmental Panel's Working Group on the FGGE Data Management, Washington, DC, USA (October)

CAS- Working Group on Weather Prediction Research, Moscow, USSR (October)

6th Climate Diagnostic Workshop, New York, USA (October)

"Trends in information processing systems" and 11th Annual Conference of the Gesellschaft für Informatik, München, Federal Republic of Germany (October)

International School of Meteorology of the Mediterranean, Course in Weather Prediction by Fine Mesh Models, Erice, Italy (October)

Fifth Conference on Numerical Weather Prediction, Monterey, California, USA (November)

WMO Symposium on Meteorological Aspects of Tropical Droughts, and informal WMO meetings of experts on Tropical Disturbances and the associated rainfall, New Delhi, India (December)

In addition to this, members of staff visited a number of universities and meteorological institutes such as the Techniques Development Laboratory of the National Weather Service, Silver Spring, USA; the Canadian Meteorological Centre, Montreal; NMC, Washington, DC, USA; the Goddard Laboratory for Atmospheric Sciences, Greenbelt, Maryland, USA; GFDL, Princeton, New Jersey, USA; NCAR, Boulder, Colorado, USA; the Centre National d'Etude des Télécommunications and the Centre de Recherche de la Physique de l'Environnement, Paris, France; Fujitsu Research and Development, the University of Kyoto, NEC, and Hitachi, Japan.

Visits were made to the national meteorological services of nine of the Member States, and members of staff participated in various planning group meetings and committees of WMO.

Attendance has also been maintained at meetings of the Co-ordinating Committee of Government Budget Experts of the Co-ordinated Organizations, the Committee of Heads of Administration, and the Standing Committee of Staff Associations of the Co-ordinated Organisations.

Annex 1

ECMWF Publications 1981

Technical Reports

No. 23 Comparison of Medium-Range Forecasts made with models using Spectral or Finite Difference Techniques in the Horizontal

No. 24 On the Average Errors of an Ensemble of Forecasts

No. 25 On the Atmospheric Factors affecting the Levantine Sea

No. 26 Tropical Influences on Stationary Wave Motion in Middle and High Latitudes

No. 27 The Energy Budgets in North America, North Atlantic and Europe based on ECMWF Analysis and Forecasts.

No. 28 An Energy and Angular Momentum Conserving Finite-Difference Scheme, Hybrid Coordinates and Medium Range Weather Prediction

Workshops

On Radiation and Cloud-Radiation Interaction in Numerical Modelling, 15 - 17 October 1980.

On Implementation of GKS at ECMWF, 14-15 May 1981

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

GARP - FGGE

Daily Global Analysis - Part I: December 1978 to February 1979

Daily Global Analysis - Part II: March 1979 to May 1979

ECMWF Newsletter

No. 7	February
No. 8	April
No. 9	June
No.10	August
No.11	October
No.12	December

ECMWF Computer Bulletins

Working limits, defaults and installation parameters

An introduction to loaders

FILESET - A Cyber file compaction package

Use of interactive keyboard terminals

EDIT

ECMWF Forecast Reports

No. 11	November 1980
No. 12	December 1980
No. 13	January - March 1981

Other Publications

ECMWF Forecast Model Documentation Manual, Vol. 2:
Organisation of the Model.

Annex 2

Publications by Members of Staff

Arpe, K. and Oriol, E. 1981 Energy calculations at ECMWF. Proceedings of the *Sixth Annual Climate Diagnostic Workshop, NOAA*

Bengtsson, L. and Kållberg, P. 1981 Numerical simulation - assessment of FGGE data with regard to their assimilation in a global data set. *Adv. Space Res. Vol. 1. pp.165-187, Pergamon Press, Oxford, UK*

Bengtsson, L. 1981 Numerical prediction of atmospheric blocking - A case study. *Tellus, 33, 19-42.*

Bengtsson, L. 1981 Data analysis, initialisation and data assimilation. International Conference on preliminary FGGE Data Analysis and Results. (Bergen, Norway, 23-27 June 1980) *WMO, Geneva, 162-185.*

Bengtsson, L. 1981 The Weather Forecast. Bergeron Memorial Volume. *Pure and Applied Geophysics, 119, No. 3, 515-537.*

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Böttger, H. and Pümpel, H.1981 "Das Europäische Zentrum für mittelfristige Wettervorhersage (EZMW) - ein Überblick" *Beilage zur Berliner Wetterkarte,* December.

Cubasch, U. 1981 The performance of the operational forecast model. Preprints of the Fifth Conference on Numerical Weather Prediction, 2-6 November 1981, Monterey, California, 80-82.

Ducrot, A., Lemaire, A. and Watkins, H. - "A GKS implementation for meteorological applications" Proceedings of Eurographics 1981 (Darmstadt September 1981).

Källén, E. 1981 The nonlinear effects of orographic and momentum forcing in a low-order, barotropic model. *Journal of the Atmospheric Sciences, 38 2150-2163*

Lorenc, A.C. 1981 A global three-dimensional multivariate statistical interpolation scheme. *Monthly Weather Review, 109, 701-721.*

Savijärvi, H. 1981 An iterative time integration scheme with selective damping. *Monthly Weather Review, 109, 901-902.*

Savijärvi, H. 1981 Energy budget calculations from FGGE analyses and ECMWF forecasts. Proceedings of the International Conference on Preliminary FGGE Data Analysis and Results, Bergen, 536-541.

Simmons, A.J. and Burridge, D.M. 1981 An Energy and Angular-Momentum Conserving Vertical Finite-Difference Scheme and Hybrid Vertical Co-ordinates. *Monthly Weather Review, 109, 758-766.*

Temperton, C. and D.L. Williamson 1981 Normal mode initialization for a multi-level grid-point model. Part I: Linear aspects. *Monthly Weather Review, 109, 729-743.*

Williamson, D.L. and C. Temperton 1981 Normal mode initialization for a multilevel grid-point model. Part II: Nonlinear aspects. *Monthly Weather Review, 109, 744-751.*

Woods, J.A. 1981 The impact of starting ECMWF medium-range forecasts from 00Z analyses with short data cut-off times. Preprints of the Fifth Conference on Numerical Weather Prediction, 2-6 November 1981. Monterey, California, 19-22.