Annual Report 1980

European Centre for Medium Range

Weather Forecasts

Contents

Foreword

A number of notable events in the development of the European Centre for Medium Range Weather Forecasts took place in 1980.

The initiation of a daily distribution of the Centre's forecast products on 1st August was probably the most important. The reaction of Member States receiving these forecasts and the results of verification tests conducted by the Centre indicate that the accuracy of the forecasts up to day five at least, compares more than favourably with that of other major centres producing similar type forecasts. The production of forecasts with an acceptable level of accuracy for periods of six to ten days ahead now constitutes a major challenge to the skills and resources of the Centre. I am confident that this problem will engage the full attention of all concerned in the Centre in the coming years.

At its twelfth session the Council agreed that some of its forecasts for periods up to five days ahead could be made available to States which are not members of the Centre. The offer is being considered by the World Meteorological Organisation.

A draft Co-operation Agreement between the Government of Iceland and the Centre had reached a stage where it was ready for acceptance by the end of the year.

During my year as President of the Council, I had the pleasure of working closely with many people of the Centre. I wish to express my thanks and appreciation to the Director and members of the Council for their co-operation and support; to the staff for their assistance and courtesy during my visits to the Centre; and to the chairmen and members of the Council's committees for their work in ensuring the effective use of the Centre's resources.

P.K. Rohan

Introduction

1980 has been my first year as Director of the Centre and has been marked by a number of changes in the staff, in addition to a general reorganisation within the Administration Department.

Staff Changes

Dr. Daniel Söderman, from Finland, took up the post of Head of the Operations Department early in the year. The post of Head of the Computer Division in that Department was filled later by Mr. Geerd Hoffmann, following the resignation of Mr. Rob Brinkhuysen to work for the meteorological service of the Netherlands. In the Administration Department, Mr. Hansjoachim Hartwig joined as Head of Department on 1st September. The previous Head of Department, Dr. W.D. von Noorden, left to join the staff of INMARSAT, in London, in May 1980.

Technical and Scientific Activities

Despite these changes, the work of the Centre has continued with a considerable measure of success. A landmark in its progress was the commencement of distribution of forecasts on a daily basis, from 1st August. Assessment of the Centre's forecasts now shows that they are of a very high quality for up to six days. The Chapters on the Operations and Research Departments give more information on these points.

The main efforts of the Research Department are devoted to studying the difficulties presented by the present model, including those of data assimilation, with a view to building a second-generation model which will give better-quality forecasts.

Co-ordinated Organisations

Little progress has been made with regard to the Centre's application to join the Co-ordinated Organisations. Further requests, made both by the Centre and by the European Patent Office, which is in the same position, and supported by several of the Member States' representatives in bodies of the Co-ordinated Organisations that the application be given urgent consideration by those of the Co-ordinated Organisations which have not yet agreed to it have not led to any result at this stage.

Exchange of letters constituting the Co-operation Agreement between Iceland and the Centre, 20 November 1980: Professor E. Lingelbach, Vice-President of the Council; Mr. H. Sigtryggsson, Director of the Icelandic Meteorological Office; Mr. J. Labrousse, Director of the Centre and Mr. P.K. Rohan, President of the Council.

Co-operation Agreement with Iceland

I am very happy to report that after several years of discussion and negotiations, a draft Co-operation Agreement between the Government of Iceland and the Centre was finally approved by Council and by the Icelandic Government. The Co-operation Agreement, in the form of an exchange of letters signed by myself and the Minister for Foreign Affairs of Iceland, dated 20 November 1980, came into effect on 1st December 1980. After effecting the exchange of letters on 20 November, Mr. Hylnur Sigtryggsson, Head of the Icelandic Meteorological Service, was invited to participate as an observer in the 12th Council session, which took place on 20 - 21 November.

President of the Council

Owing to his forthcoming retirement from his position as Director of the Irish Meteorological Service, it was not possible for Mr. Rohan to stand for re-election as President of the Centre's Council. Professor Lingelbach was unanimously elected to succeed him as President.

I would like to take this opportunity of wishing Mr. Rohan every happiness in the future, and to thank him, both on my own behalf and on behalf of all the staff, for the efforts he has made to help the Centre, and for the results achieved under his Presidency.

I would also like to welcome the new President, Professor Lingelbach, on whom I am sure I can rely for all the advice and assistance the Centre needs for a continuous improvement of its work and an increasing benefit to the community as a whole.

Conclusion

It only remains for me now to thank all those, in particular the Members of the Council and its Committees, and of course the staff, for their contribution towards the achievements of the Centre in 1980.

J. Labrousse

Research Department

Numerical Modelling

The Model Division has continued to develop and work mainly with the three large-scale numerical models designed for either operational weather forecasting or experimentation.

These are global/hemispheric grid-point and spectral models, and a limited-area fine-mesh model. Most experiments have been performed using the semi-implicit time-stepping scheme and the physical parameterisations developed at ECMWF. The integrations have generally been carried out with the following "standard" 15-level versions:

Grid-point model	- 1.875° grid (N48)
Spectral model	- T63, T40 and T21 (triangular truncations at total wavenumbers 63, 40 and 21 respectively.)

A limited number of experiments have been carried out using higher vertical or horizontal resolution.

Use of these models by an increasing number of Member States has occurred during 1980.

Spectral/Grid-Point Comparisons

The spectral model at resolution T63 requires about the same computer resources as the operational N48 grid-model to produce a ten-day forecast. Preliminary forecasts gave encouraging results, and the model has thus been run once a week on a quasi-operational basis from September 1979 to August 1980 in order to obtain a detailed comparison of its performance with that of the operational model.

Although the two models often give very similar forecasts, both objective and subjective assessments show a significant improvement to result from use of the spectral model. The improvement is largest at the surface and in the mean appears as an increase of about 6 hours in the objective estimate of the period for which the forecasts are useful (Fig. 1). Larger differences, amounting to an increase in predictability of around one day, are found in about 10% of cases.

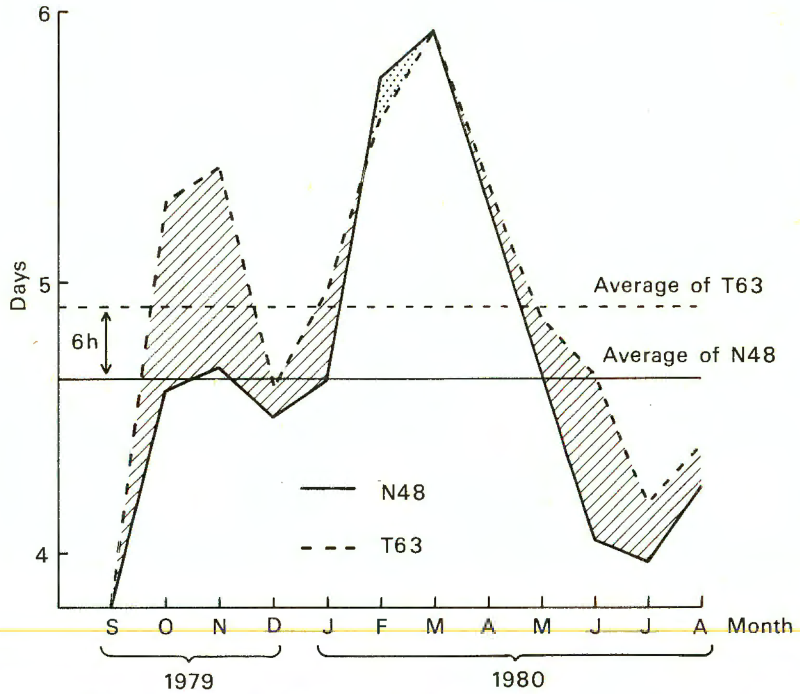


Fig. 1 **The seasonal variation of the mean period of usefulness (in days) for forecasts using the operational grid-point model (N48-solid line) and the spectral model (T63-dashed line). The period of usefulness is here defined objectively as the time taken for the anomaly correlation coefficient to drop below 60%.**

The systematic errors (see below) of the two models are, however, very similar.

Work has begun on the incorporation of the spectral model within a revised, more flexible forecasting system with a view to operational implementation.

Systematic Errors

The rapid deterioration of the quality of the operational forecast beyond day 5 is partly due to the evolution of systematic errors during the forecasts. In 1980 therefore a study of these errors began. As their presence seemed to be dependent on the forecast model and independent of the initial flow, extended integrations up to 50 days were performed and investigated. Thereby a more complete description of the systematic deficiencies of the model could be obtained.

The principal errors are as follows:

1. A cooling of the lower stratosphere by up to 12°C in 50 days with an upward displacement of the troposphere by about 100 mb.

2. A cooling and drying of the middle troposphere.

3. A substantial warming and moistening of the boundary layer.

4. An overdevelopment and a reduced decay of individual cylones propagating too far eastwards over the continents. In the mean this appears as an overintensification and eastward shift of the Aleutian and Icelandic low pressure centres when compared with either climatology or an individual monthly average (see Fig. 2). It is also associated with too high temperatures over the western parts of the continents in winter, and too low temperatures in summer.

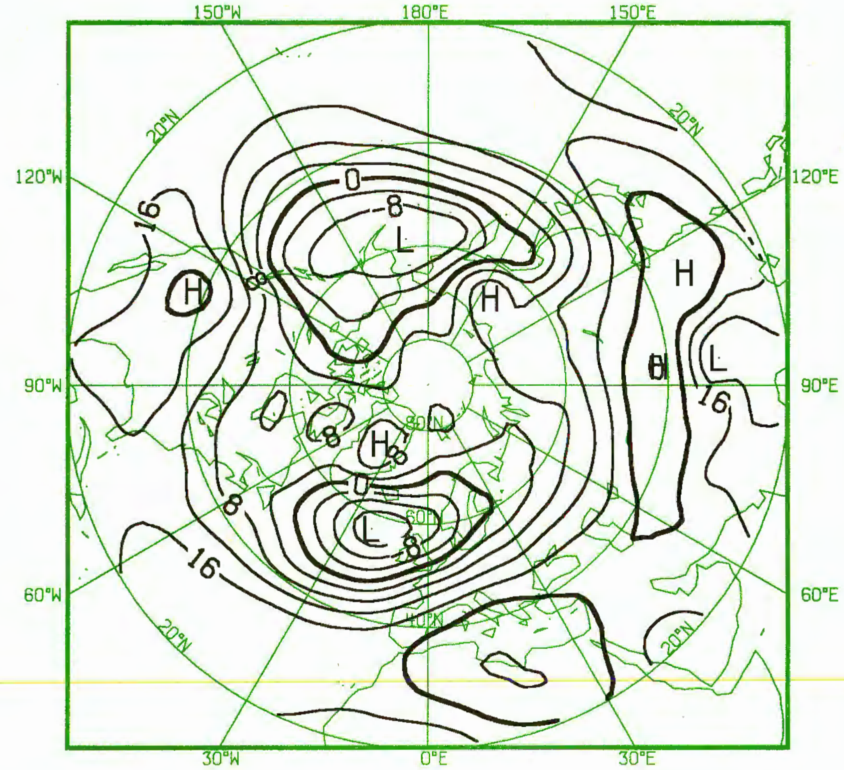
5. An underestimate of the strength of the Hadley circulation and rainfall in the Tropics.

6. A poleward shift of the subtropical jet in both hemispheres.

As it is not clear to date which part of the model formulation is causing these systematic errors, a series of sensitivity experiments has been made in which the formulation of the physical or dynamical processes is partly changed. Little or no sensitivity has been found to any of the changes yet made.

Model Development

The orography and coastlines used in the operational model since August 1979 were derived from data originally prepared for a lower resolution GFDL general circulation model. This gives a highly smoothed representation and results in a number of obvious local deficiencies in the quality of forecasts. Alternative distributions have been derived from data with a 10' resolution made available by the U.S. Navy, and a number of analyses and forecasts have been completed. Some improved local features have been noted, although the impact on the larger scales of motion is at present mainly confined to the zonal part of the flow. Further assessment is continuing with the aim of introducing a more realistic topography into operations in 1981.



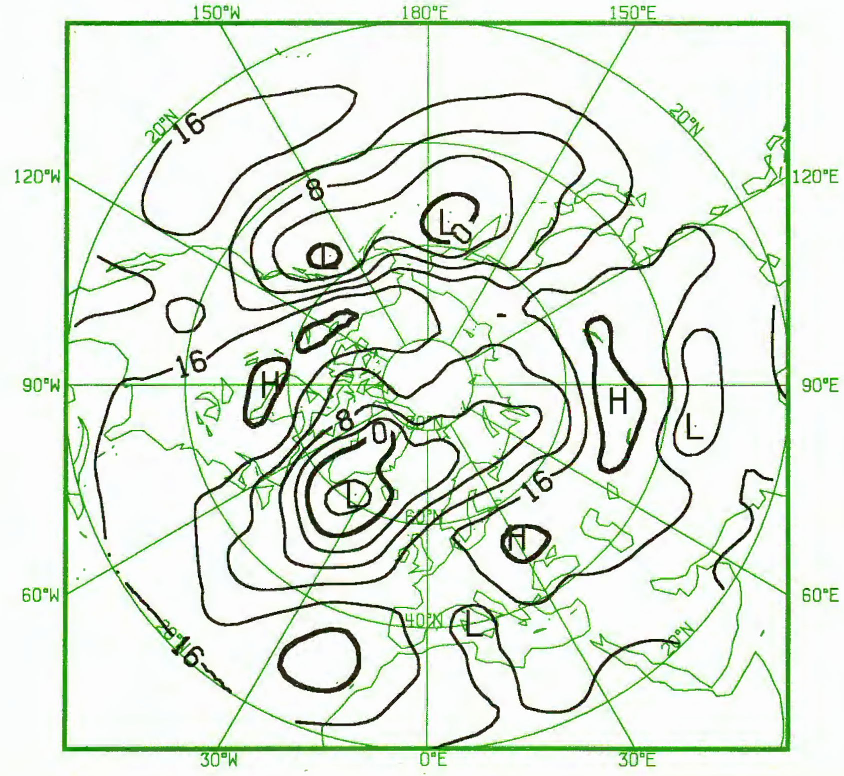


Fig. 2 **24 day means of 1000 mb heights. Contour interval 4 dkm.**
Upper panel: Day 25-48 of the model's forecast from 16 January 1979.
Lower panel: EC Analysis February 1979.

A finite difference formulation of the primitive equations has been developed for a general pressure-dependent terrain-following vertical coordinate, and a semi-implicit version with complete parameterization schemes programmed for the grid-point model. Preliminary experiments show some small improvements in forecast quality to result from use of a "hybrid" coordinate which tends continuously from sigma towards pressure as the pressure decreases. Use of such a coordinate should reduce vertical interpolation errors at upper levels in data assimilation cycles, and a series of tests in both data assimilation and forecasting will take place during 1981.

A new parameterization of convection has been developed by visiting scientists, M.J. Miller and M.W. Moncrieff of Imperial College, London. This has been incorporated for test forecasts, as has the scheme proposed by Arakawa and Schubert. Comparisons of the Centre's radiation scheme with that developed at the University of Cologne have also been carried out. A faster radiation calculation is being developed to allow inclusion of a diurnal cycle in the model.

Dynamical Studies

A limited effort has also been made into investigations of a more fundamental nature. Non-linear barotropic models have been used to study a mechanism for blocking and a computation of steady linearly-forced wave motion has been carried out using much of the formulation of the multi-level grid-point model. The aim of these more idealized studies is to improve our understanding of atmospheric predictability and of the systematic model errors.

Data Assimilation

Work on data assimilation this year has been mainly concerned with further development of the operational and FGGE analyses. By the end of the year the analysis system was more internally consistent, more robust, more efficient and better adapted to the forecast model than one year ago. Two problems that gave particular concern during the year seem close to a resolution. These were firstly an excessively long spin-up time for the physical parameterizations in the forecast and secondly the excessive damping of tropical divergence fields by the initialization scheme.

Data Selection

Substantial gains in computational efficiency were achieved by a revision of the data selection procedure and by associated software changes. The analysis is based on optimum interpolation performed for ensembles of grid points within successive boxes. The selection of data to be used in the analysis for a particular box has been reduced, both in terms of the area covered and the number of data selected for each analysis level and variable. The impact of these changes, in both analyses and forecasts, was seen to be very small, but the computational gains are substantial.

Interpolation of Analysis Increments

The analysis is performed on standard pressure levels; the forecasting model however is in sigma-coordinates. Consequently transformations sigma → p (p → sigma) are required before (after) the analysis. Such transformations need to be done with care, particularly since the forecast model has better vertical resolution in the boundary layer than the current analysis scheme. Formerly the p → σ transformation was done by vertical interpolation of the p-level analysed fields ("full field" interpolation). A more appealing procedure is to vertically interpolate not the analysed fields but the increment fields (i.e. differences between first guess and analysis). This should help preserve the vertical structure of the sigma-level first guess field; it also guarantees no change in the model fields in data void regions. Comparisons between the two types of interpolation show considerable differences in the ensuing boundary layer structure of the model. Figs. 3 and 4 show the vertical cross sections over Antarctica along the Greenwich meridian for fields after the p → sigma transformation, using interpolation of full fields and interpolation of increments respectively. The latter has preserved much of the original model structure, most noticeably the stable boundary layer over high terrain and a relatively unstable structure over the ocean.

The use of interpolation of increments in the analysis scheme has little impact on the model's mid latitude predictive skill. It does, however, produce significant changes for the better in terms of the global convective activity in the first few days of a forecast (such activity now has a reduced spin-up time) and also the global sensible heat input at the surface, previously excessively high in the first 12 hours of the forecast, is now greatly reduced.

Initialization

One problem with the normal mode initialization procedure concerns the damping of the tropical divergence fields. In particular the Hadley circulation is severely disrupted in the initialized data. It appears that the problem may be overcome by initializing fewer vertical modes. The stability of the revised initialization was under test at the year's end. It is difficult at this point to estimate the impact on the forecasts.

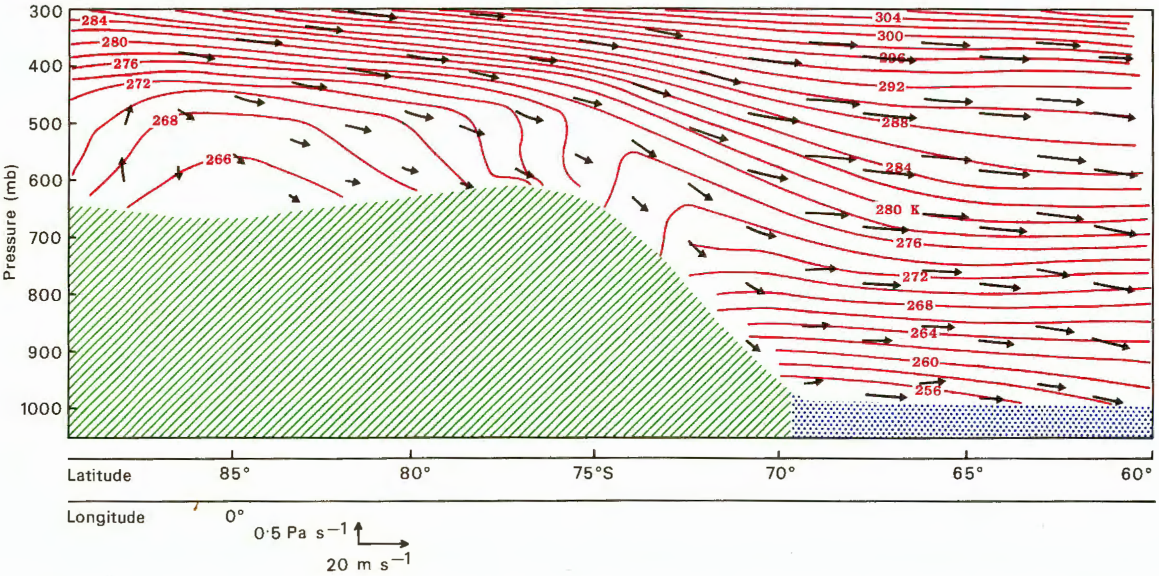


Fig. 3 Cross-section from 12 GMT, 8 September 1980. Red curves are isolines for the potential temperature; arrows indicate wind direction and speed according to the scale given below the figure. Temperature and wind fields arrived at through an interpolation of the full fields (not initialised).

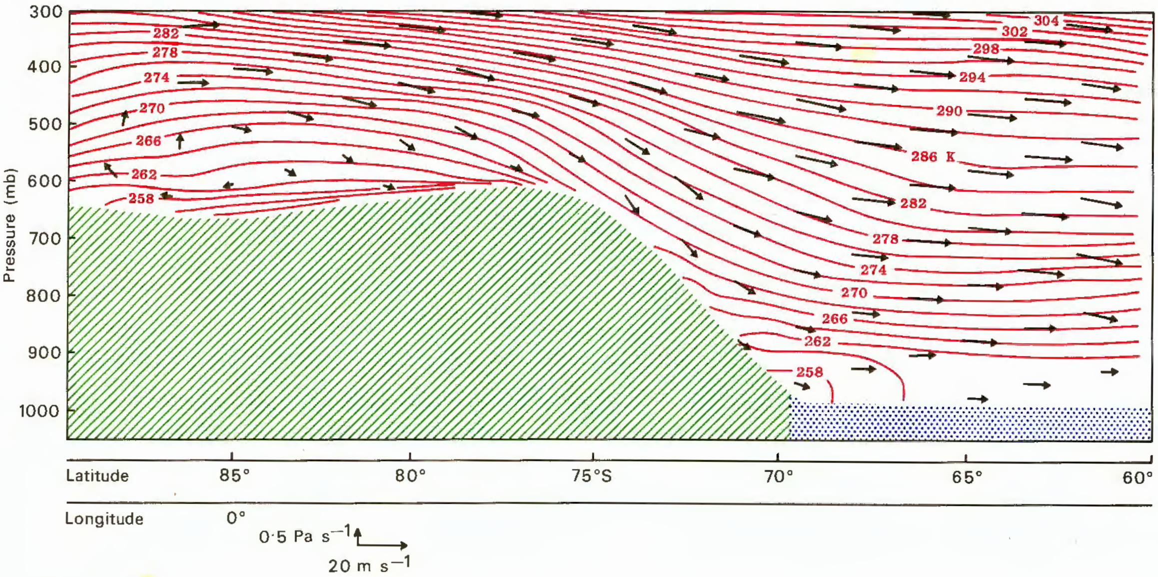


Fig. 4 Same as for Fig. 3 but interpolation of increments (not initialised).

FGGE Analysis

By the end of the year the production of level III-b FGGE analyses had passed the halfway point and had almost reached the end of the second special observing period.

All of the FGGE observing systems behaved well and the data, with few exceptions, is of high quality. The analyses of the first half of the FGGE year show excellent temporal and spatial continuity and an excellent fit to the observations, both objectively and synoptically.

Of particular note are the analyses of the divergent wind. In the tropics this shows a striking synoptic correlation with areas of deep convection. Fig. 5 shows the mean 200 mb velocity potential field for January 1979. (The divergent wind blows normal to the contours). The major areas of convective activity over South America, Africa and East of Indonesia are clearly indicated.

Observing system experiments have also been started and comparison of FGGE versus post-FGGE observing systems shows that especially on the southern hemisphere both the post-FGGE analysis and forecast are clearly inferior.

Diagnostics

The diagnostic section contributes to the work of the Research Department through the development and use of a wide range of diagnostic tools. Two such sets of diagnostics are now in routine operational use.

One set of diagnostics, calculated on pressure levels, is designed to study zonally averaged circulation statistics for both the analyses and the forecasts. Means variances and covariances (eddy transports) for all of the significant dynamical quantities are calculated. The study of monthly means of these quantities for both the analyses and the day 1, day 2, forecasts, etc., sheds useful light on systematic errors in the forecasts.

The second set of diagnostics which are run on every operational analysis and forecast are designed to produce regional energy budgets for selected regions, e.g. certain latitude bands, land and sea areas, or particular oceans or continents. In such calculations the estimation of boundary fluxes has always been troublesome. For this reason the operational calculations are made in model coordinates. Diabatic sources and sinks are estimated as residuals.

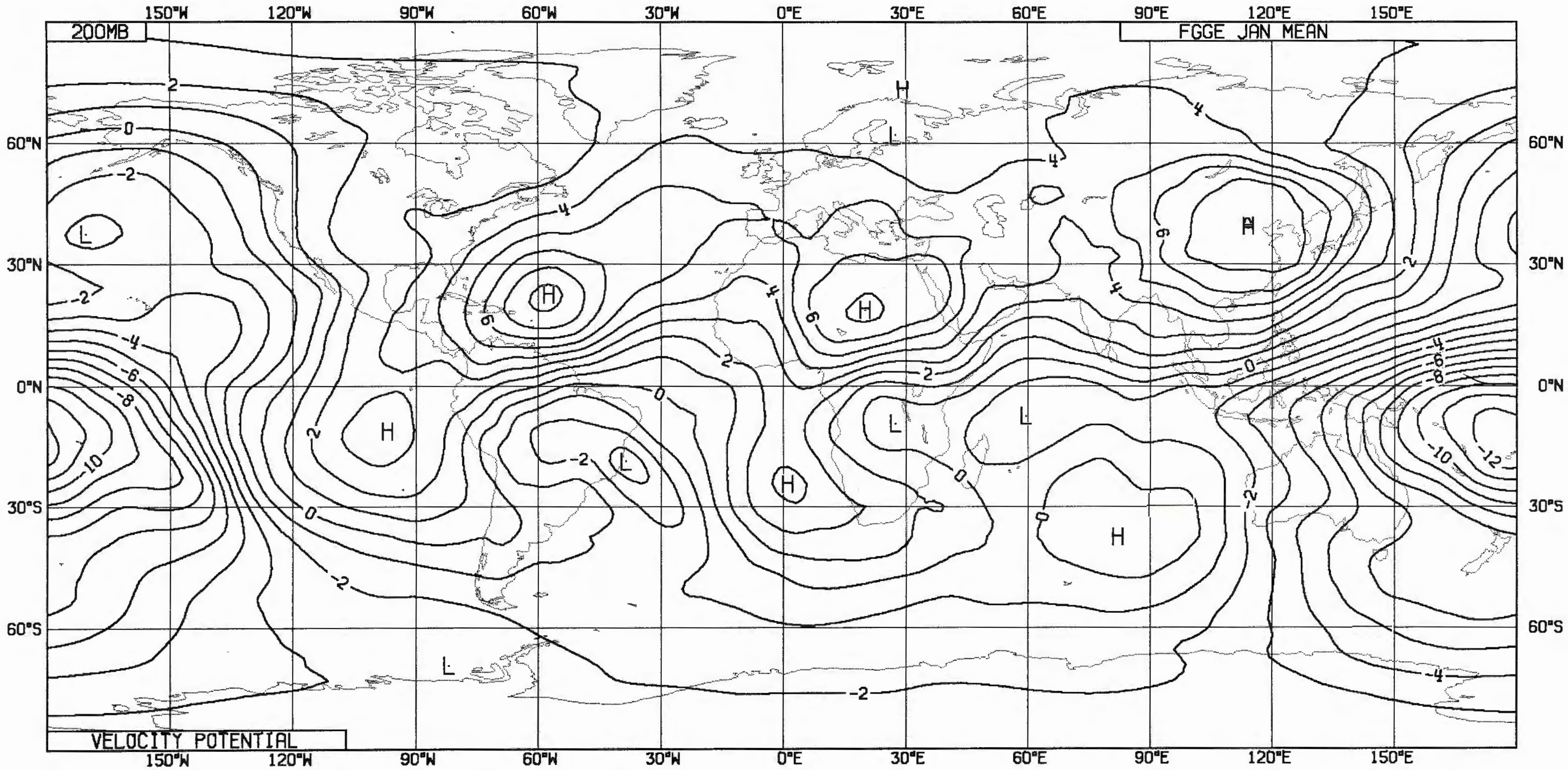


Fig. 5 Mean 200 mb velocity potential field for January 1979

Verification of forecasts of extreme temperatures at 850 mb over Europe

Besides its responsibilities in the area of diagnostics, the section also has concerns in the area of verification. One of its activities in this area is to consider the usefulness of forecast results, often measured by RMS-errors or correlation coefficients. Such crude methods may be misleading. Take, as an example, the skill of the 5-day point forecasts of 850 mb temperatures, for the period from December 1979 to February 1980 in the area of Europe (15W to 40E, 30N to 75N 2.5 degrees resolution). During these three months the temperatures on the 5th day were forecast too cold by 1.67 K on the average and the RMS-errors were 4.57 K. For comparison the RMS-errors for two no-skill forecasts were also calculated. These were a forecast of the climatological value and a forecast of no change during the forecast period (persistence); the RMS-errors were 3.9 K and 4.7 K respectively. These numbers would seem to indicate that the ECMWF-forecasts are of little value, because a climatological forecast would give better results.

On the other hand, one should keep in mind that the user of forecasts is mostly interested in extreme events or deviations from climatology and for that purpose a climatological forecast is quite useless.

Contingency tables relating occurrences of temperature anomalies (departures from climatology) with forecast temperature anomalies, for the 27531 forecasts involved, give a clearer picture. Fig. 6 shows such contingency tables with 9 anomaly categories for the ECMWF, and for persistence, forecasts. The numbers have been presented as percentages so that for each column (i.e. for each anomaly class) the total is 100. The ideal forecast would give 100 in the boxes on the diagonal and zero elsewhere. A climatological forecast would give 100, on a horizontal line in the category $-1 < \Delta T < \infty + 1$ and zeros elsewhere. The ECMWF-forecasts show a clear diagonal structure. If we consider the first column on the left, we see that out of all cases with observed temperature anomalies of more than -9 K the ECMWF-model predicted 34% of the cases correctly, while in a further 30% of those cases the temperature was forecast to be in the category -6 to -9 K. If one compares the ECMWF-forecast values with those of the persistence forecast, it becomes clear that the 5-day temperature forecast still has a lot of skill, especially when large anomalies occur. It also shows that the ECMWF-model generally predicts too cold temperatures, which can of course be taken into account when using the forecasts.

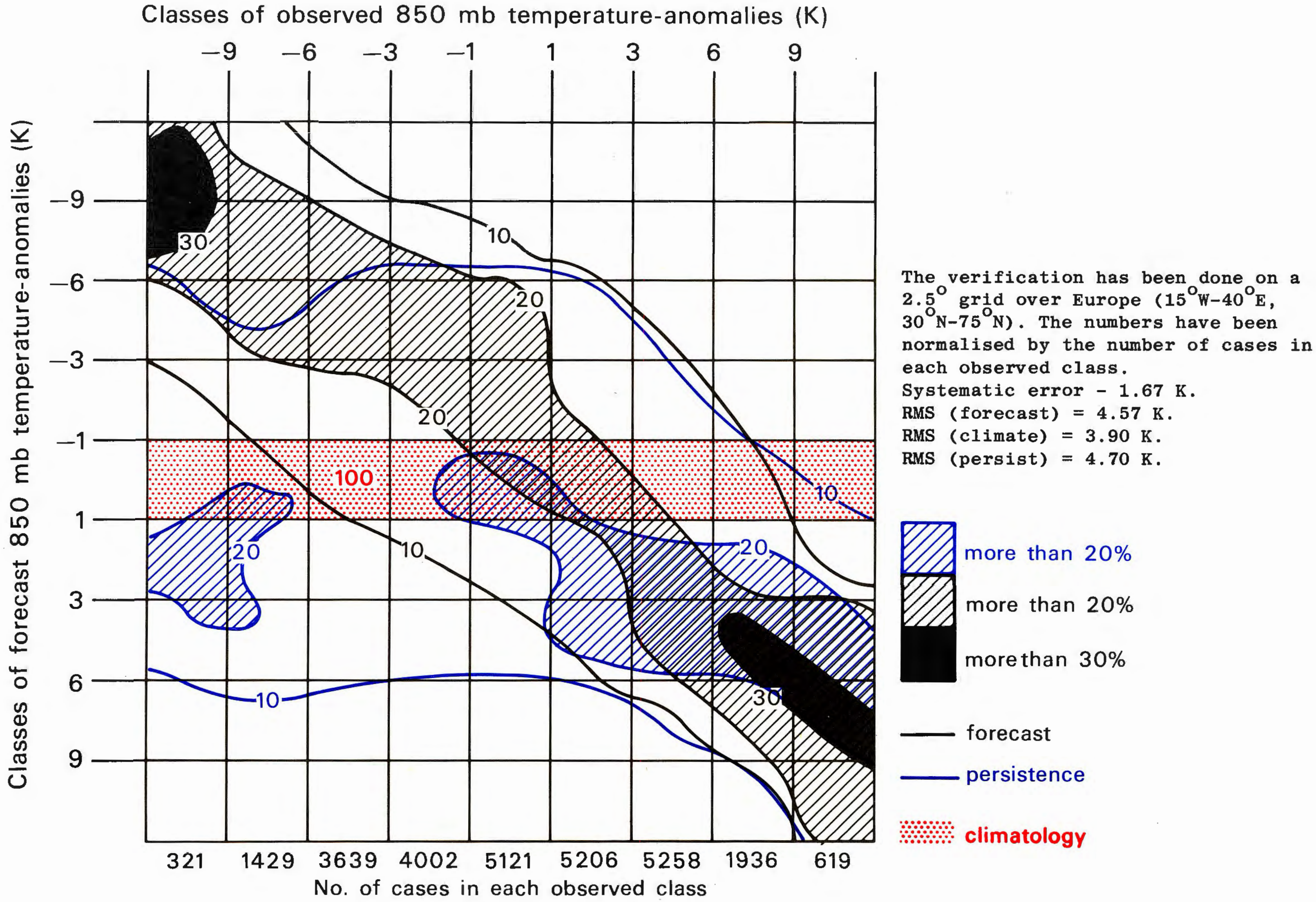


Fig. 6 Contingency tables of 850 mb temperature anomalies for day 5 forecasts. All forecasts between 1st December 1979 and 29 February 1980 (5 forecasts a week) are included.

Visting Scientists

During 1980, the Research Department employed the following visiting scientists, consultants or experts:

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

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

Dr. Xing-Yuan Du, Central Meteorological Service, People's Republic of China.

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

Dr. Karl Johannessen, National Weather Service, Silver Springs, Maryland, United States of America.

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

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

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

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

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

*On secondment.

Operations Department

The foremost task of the Operations Department, to carry out the production operationally on a routine basis of medium-range weather forecasts has been successfully continued throughout 1980. Up to 31 July, forecasts were produced 5 nights a week, and since then every night. Only two forecasts were missed from the scheduled production, although there have occasionally been delays of a few hours, usually as a result of computer hardware problems.

Developments in the Centre's Computing Facility and Service in 1980

The CDC CYBER 175 memory was augmented by 64K words, to bring the main memory up to a total of 256K words, the maximum possible. Installation of four 885 disk units began during November, replacing eight 844 disk drives. When this change has been completed early in 1981, the total on-line space will be increased from 376 to 743 M words. In addition, the four 7154 disk controllers are being replaced by six 7155 controllers which can handle both 844 and 885 disks.

These changes have had the expected beneficial effects on the CYBER service. Memory utilisation has increased and the extra memory has resulted in improvements in peak CPU usage from 55% to around 65%. The long backlogs of CYBER jobs experienced earlier in 1980 were temporarily eliminated but, by the end of the year, demand had again increased and delays were again being experienced.

During 1980, there was also considerable pressure to expand the Centre's local VDU terminal network. Following the installation of a Gandalf Private Automatic Computer exchange (PACX) in October to enable handling of more local terminal connections to the CYBER, the local terminal network was substantially expanded by the addition of 24 more Newbury VDU terminals to the 24 terminals already available.

The configuration of the ECMWF computer system, as it will stand following completion of the disk upgrades on the CYBER, is given in Fig. 7.

As an addition to the computing service offered at ECMWF, output on microfiche of both text and graphical material was made available. Outside bureau services were used to produce the microfiches from information sent on magnetic tape. The provision of this service resulted in an appreciable reduction in paper consumption as well as facilitating the storage and postage of computer outputs.

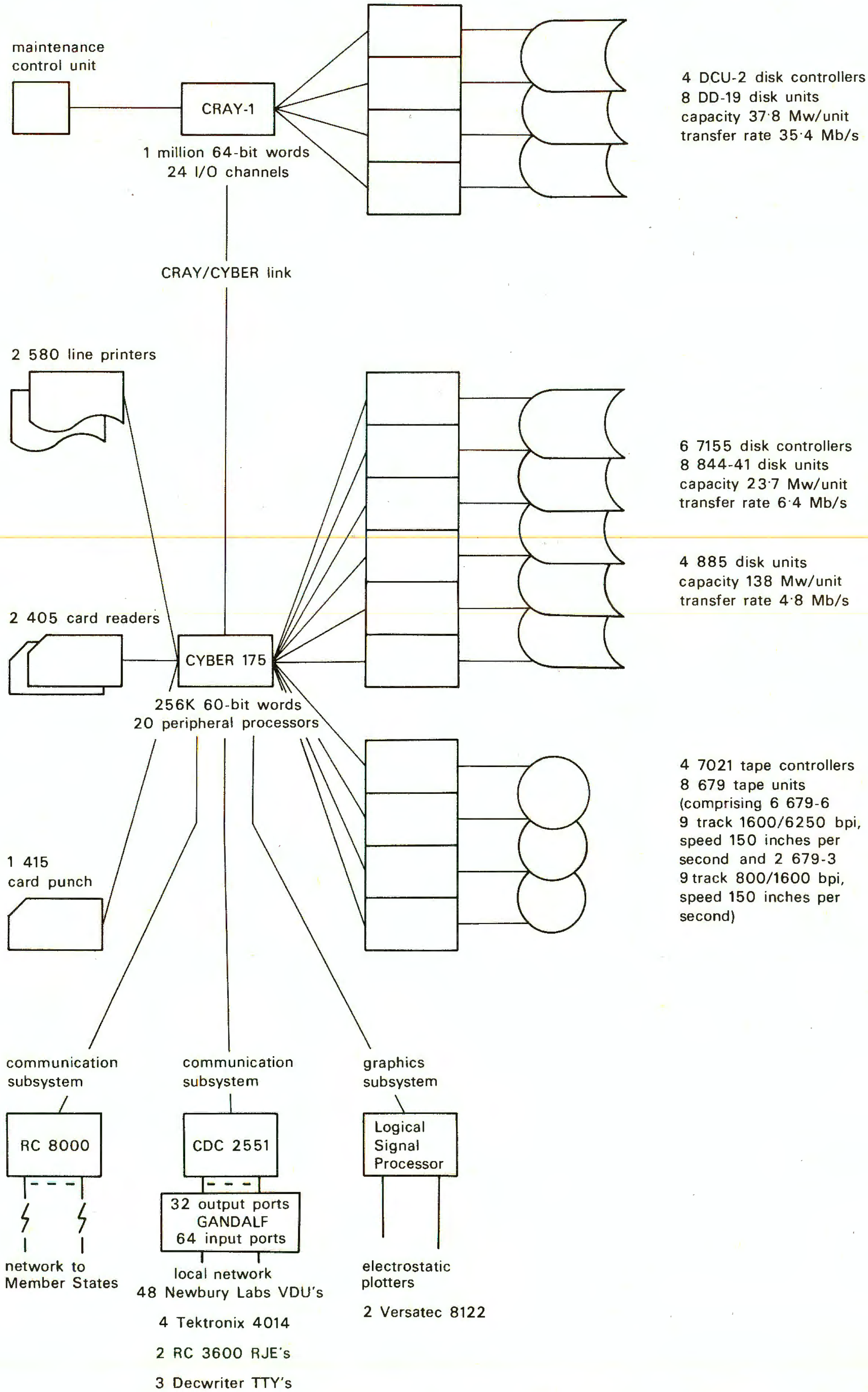


Fig. 7 Configuration diagram of ECMWF Computer System

The total throughput and availability of the CRAY-1 and CYBER 175 systems in 1980 is given in Table 1 below.

Table 1. Total throughput of the CRAY-1 and CYBER 175 systems in 1980

	CRAY-1	CYBER 175
Number of jobs run	190616	1138209
Number of computing units used (million units)	4.2	3.9
Number of hours central processor time	4185.0	3519.5
Average availability (%)	98.5	97.6
Mean time between hardware faults (hrs)	75.2	118.4
Mean time between software faults (hrs)	111.9	100.5
Overall time between any faults (hrs)	45.2	78.0

Table 2 gives in detail the number of computing units used by Member States in 1980, and by various sub-projects within the Centre such as FGGE.

Table 2. Computer usage 1980 (K units)

	CRAY	CYBER
Belgium	0	0
Denmark	1	0
Germany	16	0
Spain	3	0
France	106	21
Greece	0	0
Ireland	0	0
Italy	16	2
Yugoslavia	2	1
The Netherlands	2	1
Austria	0	0
Portugal	0	0
Switzerland	0	0
Finland	1	2
Sweden	17	26
Turkey	0	0
United Kingdom	151	81
Member States TOTAL	315	134
Member States Special Projects	3	9
Operational forecast production	1334	1534
Operational forecast trials	369	260
FGGE	473	515
Centre Research and Development	1696	1405
OVERALL TOTAL	4190	3857

The CRAY/CYBER Link

An important innovation in the area of the CRAY/CYBER link has been the availability as from November of operator display and control facilities, greatly aiding operator control of the CRAY-1 via the CYBER console. Changes to the link software have improved reliability; at the end of 1979 the mean time between failure was about 10 hours, in mid-1980 about 35 hours and at the end of 1980 more than 168 hours, that is less than one failure per week. The throughput of the link has increased steadily during the year as shown in Table 3.

Table 3. Throughput and statistics concerning the CRAY/CYBER link in March and October/November 1980

	March 1980	October/November 1980
Average load (Mbits/sec)	0.3	0.6
Peak load (Mbits/sec)	6	8
Files transferred per week		
- Permanent files	5500	6500
- Queue files	11000	16000
Total (64-bit) words transferred per week	1.9×10^9	3.4×10^9

Telecommunications Aspects

Gradual progress towards the final goal of a private dedicated telecommunications network of medium-speed (2400 or 4800 bps) lines linking the Centre and all the Member States continued in 1980. During the year, medium-speed circuits between the Centre and Denmark, Germany, and the United Kingdom became operational, and the lines to France and Ireland were being tested at the end of the year. The status of, and planned implementation schedule for the remaining medium-speed links are given in Table 4. The plan for the remaining medium-speed links is that approved by Council at its 12th Session in November 1980, following the recommendations of the Technical Advisory Committee at its session held in June 1980.

Table 4. Status of, or planned implementation schedule for the ECMWF telecommunications network at 31 December 1980

Member State	Medium speed line	Low-speed line
Belgium	Planned July 1981	-
Denmark	Established April 1980	-
Germany	Established February 1980	-
Spain	Planned May 1981	Yes (50 baud)
France	Planned September 1980 (1)	Yes (50 baud)
Greece	Planned September 1981	Yes (100 baud)
Ireland	Planned June 1980 (2)	-
Italy	Planned June 1982	Yes (50 baud)
Yugoslavia	Planned January 1982	Yes (50 baud)
The Netherlands	Planned February 1981	Yes (100 baud)
Austria	Planned April 1981 (3)	-
Portugal	Planned May 1981 (4)	Yes (50 baud)
Switzerland	Planned January 1984	-
Finland	Planned January 1981 (5)	-
Sweden	Established November 1979	-
Turkey	Planned January 1982	Yes (50 baud)
United Kingdom	Established March 1980	-

Notes:

(1) Implementation delayed: full operation expected February 1981.

(2) Implementation delayed: full operation expected January 1981.

(3) Now delayed to August 1981

(4) Now delayed to September 1981

(5) Now delayed to March 1981.

Progress was also made in 1980 in the development of the Centre's telecommunication facilities. Software allowing transmission of two or more files simultaneously in one direction and also service selection ("multi-streaming" software) was designed, introduced and became operational. There can now, for instance, be simultaneous transmission of products and output for the remote batch jobs to Member States. The Centre's communications system passed final acceptance at the end of August. Additional hardware is being purchased to provide duplication of the essential elements of the system and thereby increase its reliability. Of this equipment, the second Regnecentralen 8000 computer (i.e. the computer at the heart of the Centre's telecommunications processing facility) is available as a test machine.

Graphical Facilities

Extensive use for operational and research purposes is made of the Centre's graphical facilities comprising two Versatec 8122 electrostatic plotters connected on-line to the CYBER 175. An Aydin colour graphics display terminal was acquired by the Centre in December, providing 1024 x 1024 resolution colour display (16 colours) and with 128 Kbytes memory and a 5 Mbyte dual disk.

User service

During 1980, the first phase of the Centre's software library was released for general use, comprising routines or sets of routines for various specific areas of general computing (e.g. fast Fourier transforms, file control routines). Accounting for, and to a limited extent, control of, the use of the Centre's computing resources (i.e. CRAY-1, CYBER 175 and CYBER 175 permanent file space) was introduced.

Operational forecasting at the Centre

The routine production of operational medium-range forecasts at the Centre has been carried out throughout 1980. Up to 31 July 1980, forecasts were produced 5 nights a week and, since then, every night. Significant effort has been devoted to improving the reliability of forecast production and consideration given to determining the optimum schedule for the daily routine. In 1980 only two forecasts were missed from the Centre's scheduled production, one in January and one in March. There have, on less than a dozen occasions, been delays of a few hours in the production of the forecast, for example due to computer hardware problems.

During 1980, products have been distributed to the majority of Member States. Forecasts are disseminated as grid-point data in a coded form over the telecommunications links as available. The range of products from which Member States can select to meet their own particular forecasting requirements and needs has been considerably increased compared to the restricted set available for the very first period of operations in 1979. In 1980, many extra parameters such as winds, vertical velocities and humidity mixing ratio over any part of the globe could be taken from the Centre's system. Yet wider distribution of the Centre's products operationally can be foreseen. A decision was made at the 12th Session of Council in November that a limited set of products should be made available to non-Member States. This decision was "noted with appreciation" by the World Meteorological Organisation Commission for Basic Systems.

Developments in the Operational Activity

In addition to on-going improvements to the Centre's operational suite of programmes, and inclusion of many other tasks and facilities, there have been three particularly significant developments. Firstly, with the medium speed connections to both Germany and the United Kingdom becoming operational during 1980, it became possible to acquire the input observational data for the Centre's forecasting system continuously in real-time rather than in accumulated discrete batches as earlier. Data are now received directly from the World Meteorological Organisation's Global Telecommunications System from the Regional Telecommunication Hubs at Bracknell and Offenbach. Secondly, the supervisor controlling the running of the operational suite has been redeveloped. This new version of the supervisor will support more tasks, has improved facilities for monitoring of the suite, and overall will increase the flexibility of the operation. Thirdly, the Centre's archives of observational data, analyses and forecasts have become readily accessible and useable during 1980, following the development of generalised retrieval routines.

Studying the Operational Forecasts

As each forecast is produced at the Centre, it is examined from a meteorological point of view, both as an individual forecast and as part of the sequence of all the Centre's forecasts, to assess its realism and consistency, as well as to build up a view of systematic errors. Outputs directly from the Centre's forecasting model have been studied, but considerable attention has also been paid to other methods of presenting and interpreting the basic model outputs. The motivation for this is to attempt to display effectively the potentially meteorologically valuable part of the forecast (especially for the later periods), and to present information perhaps derived from many forecast fields in a composite form, possibly of direct use to forecasters. As well as producing, for example, mean charts for three to five day periods, and attempts to show cyclone tracks, other presentations have been developed. Fig. 8 shows an example of such a presentation, a "pseudo-satellite" picture. The humidity fields at all levels in the model at a grid-point are examined, and from the moisture content, a particular cloud cover may be expected at that grid-point. From these cloud cover predictions a mosaic can be built up which, when presented as in Fig. 8, is intended to show what would be seen by a satellite observing the model's predicted atmospheric state. Shown is the four day forecast from 16 October, and the actual verifying satellite picture for 20 October.

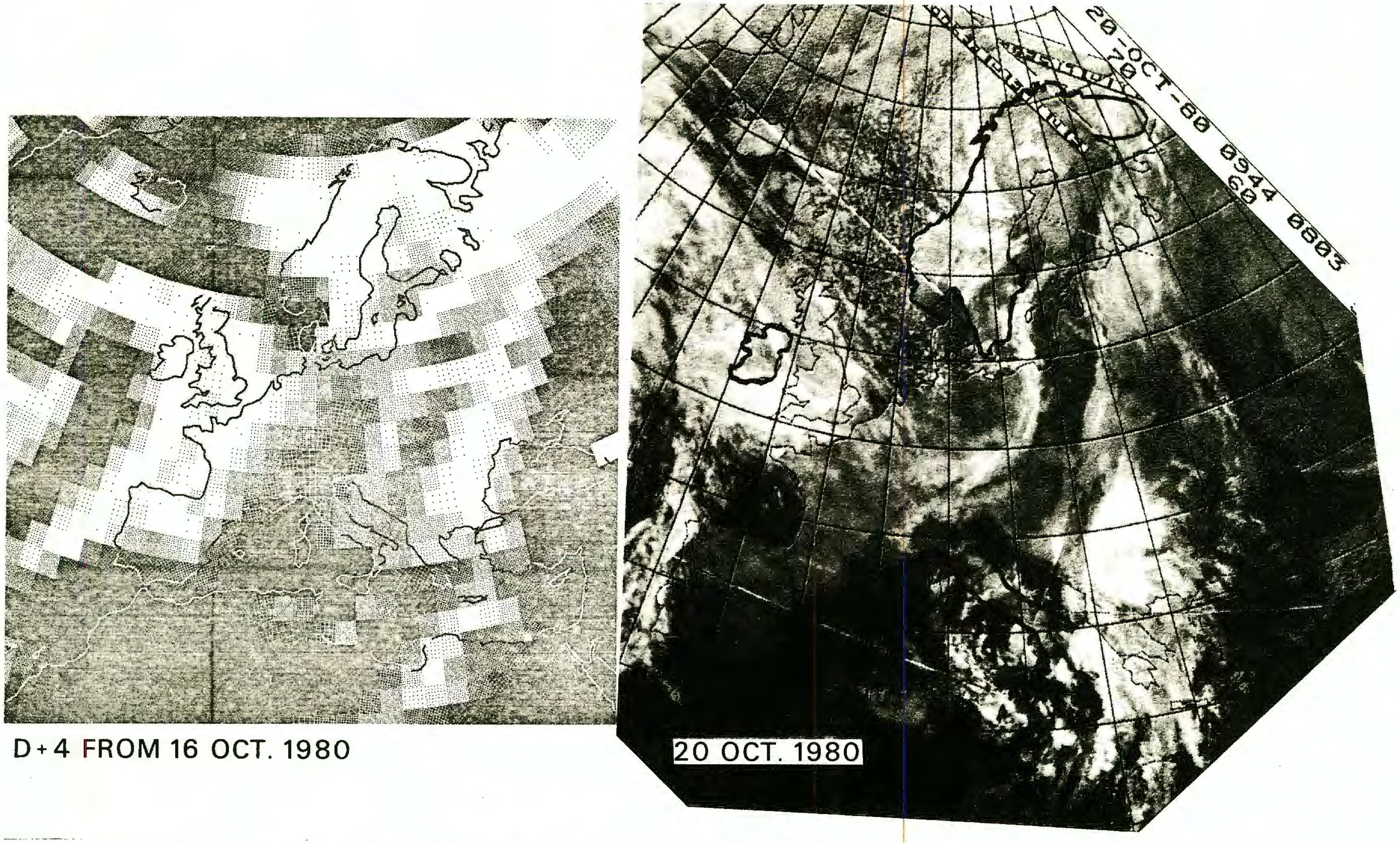


Fig. 8 Left: Model-predicted cloud in the four day forecast from 20 October 1980 in "pseudo-satellite" form
Right: Verifying infra-red NOAA-6 satellite imagery for 20 October 1980

Another form of presentation developed during 1980 is the so-called "meteogram", an example of which is illustrated in Fig. 9. This shows the evolution of cloud, temperature at a height of 2 metres, predicted precipitation, pressure and wind at a selected point site based on interpolation directly from the model fields. The particular example is for Essen in Germany for the period 4 December 1980 to 11 December 1980. The verifying data are also indicated (based on the actual observations made at the site). This method of presenting and interpreting the model outputs is a useful way of assessing the value of the model predictions and is a vital adjunct to simply studying maps of, for example, predicted precipitation.

Another approach altogether has been to compare the Centre's forecasts with those produced by other centres. Comparison with forecasts from Bracknell, Moscow, Offenbach and Washington has been very helpful in indicating situations of inherent predictability when all the forecasts tend to be similar, or uncertainty when the forecasts may be more variable. More formally, the Centre has been submitting its results for inclusion in the Numerical Weather Prediction Data Study and Intercomparison Project of the World Meteorological Organisation Commission for Atmospheric Science Working Group on Weather Prediction Research. Only limited results are so far formally available from this project, namely those giving the mean error for quarterly periods for day 1 and 3 forecasts at 1000 and 500 mb level, and only relating to the first quarter of 1980 for ECMWF forecasts. They confirm the existence of systematic error in the ECMWF forecasts, and the structure and magnitude of this error is also demonstrated. Such systematic errors are also common to the forecasts made by other centres.

Assessment and Verification of the Centre's Forecasts

The Centre's forecasts are assessed objectively, using conventional verification methods such as root mean square error or tendency or anomaly correlation coefficient, and from a "synoptic" point of view. In this latter approach, feedback from users in Member States is also naturally taken very seriously into account. The views of a meeting of forecasters from Member States at the Centre, and of the Technical Advisory Committee, are given in the chapter on the Council and Committees.

Statistics obtained from conventional verification methods are given in Table 5 which gives the mean correlation coefficients of changes and standard deviations for the Centre's forecasts carried out in January and July of 1000 and 500 mb geopotential heights and 850 mb temperature over a European area for periods up to 7 days.

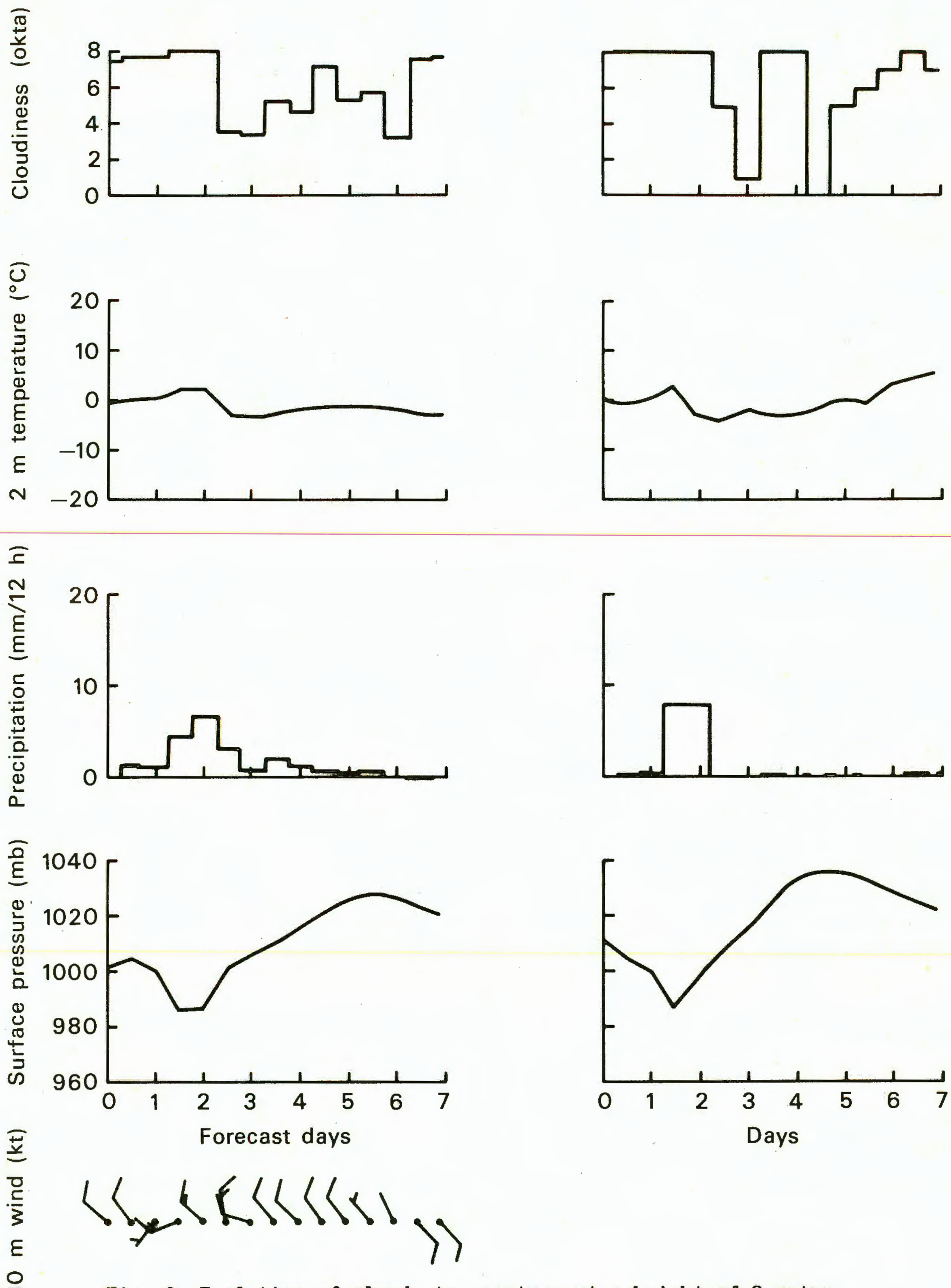


Fig. 9 Evolution of cloud, temperature at a height of 2 metres, precipitation, pressure and wind at station WMO number 10410 (Essen in Germany) for 4-11 December 1980.
Left: Prediction from 4 December based on direct interpolation from ECMWF forecast fields.
Right: Evolution based on actual observations at site.

The verifications or assessments of ECMWF products so far have mainly been in the Northern Hemisphere, or selected areas of the Northern Hemisphere. Examination of such results as are available indicate that the quality of the forecasts in the Southern Hemisphere may be somewhat lower than in the Northern Hemisphere. It has not been possible so far to assess satisfactorily the quality of the forecasts in tropical regions.

Table 5. Mean correlation coefficients of changes and standard deviations for the Centre's forecasts of 1000 and 500 mb geopotential heights and 850 mb temperature for January and July over a European area for periods up to 7 days.

	DAY						
<u>January</u>	1	2	3	4	5	6	7
Mean correlation coefficients of changes							
1000 mb height	0.92	0.89	0.82	0.73	0.63	0.52	0.45
500 mb height	0.95	0.93	0.88	0.79	0.73	0.65	0.60
850 mb temperature	0.87	0.85	0.80	0.71	0.64	0.59	0.58
Standard deviations							
1000 mb height forecast (M)	22	36	51	67	84	97	107
1000 mb height persistence (M)	58	79	90	98	105	108	105
500 mb height forecast (M) (1)	25	43	67	95	115	131	141
500 mb height persistence (M) (1)	81	118	137	154	167	170	166
850 mb temperature forecast (°C) (2)	1.7	2.4	3.2	3.9	4.5	4.9	4.9
850 mb temperature persistence (°C) (2)	3.4	4.6	5.0	5.1	5.3	5.4	5.2
<u>July</u>							
Mean correlation coefficients of changes							
1000 mb height	0.85	0.83	0.77	0.72	0.65	0.63	0.53
500 mb height	0.94	0.92	0.85	0.78	0.72	0.73	0.65
850 mb temperature	0.90	0.87	0.80	0.75	0.69	0.67	0.57
Standard deviations							
1000 mb height forecast (M)	17	26	33	37	41	46	51
1000 mb height persistence (M)	31	43	47	50	52	54	56
500 mb height forecast (M) (2)	15	26	41	52	59	64	75
500 mb height persistence (M) (3)	46	66	76	84	91	98	103
850 mb temperature forecast (°C) (4)	1.5	2.0	2.6	3.1	3.4	3.7	4.0
850 mb temperature persistence (°C) (4)	2.3	3.2	3.6	3.7	3.8	4.1	4.2

<u>NOTES</u>

(1) Climatological norm is 133 M, (2) Climatological norm is 4.9°C,

(3) Climatological norm is 91 M, (4) Climatological norm is 3.8°C.

Examples of Forecast

Fig. 10 shows a number of five day forecasts and verifying analyses in November. It is of particular interest to observe the predicted situation in the Mediterranean region. The five day forecast from 10 November in fact showed a radical change with an anticyclone replacing the originally dominating low pressure. The high pressure was then well maintained as predicted by the Centre's forecasts until nearly the end of the month, when there was a dramatic deterioration, as shown in the analysis for 30 November. This was well predicted by the five day forecast from 25 November. The Centre's forecasts thus gave a very good indication of the weather variations, and particularly the days of severe storms and cold weather over the southern Italian areas affected by the earthquake.

Visiting Scientists

During 1980 the Operations Department employed the following visiting scientists, consultants or experts:

Dr. J. Almond, Computer Centre, University of Stuttgart, Germany

Mr. T. Bloch, Centre Européen de Recherche Nucléaire, Switzerland

Dr. A. Ducrot, Institut National de Recherche en Informatique et en Automatique, France

Mr. J. Ferguson, Centre Européen de Recherche Nucléaire, Switzerland

Dr. R. Friedman, Lawrence Berkeley Laboratory, United States of America

Mr. G.-R. Hoffmann, Centre Européen de Recherche Nucléaire, Switzerland

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

Mr. A. Lindblad, Swedish Meteorological and Hydrological Institute, Sweden

Dr. A. Murphy, Oregon State University, United States of America

Mr. D. Raven, Sun Life Assurance Co. Ltd., United Kingdom

Dr. D. Robertson, Recherche en Prévision Numérique, Pêches et Environnement, Canada

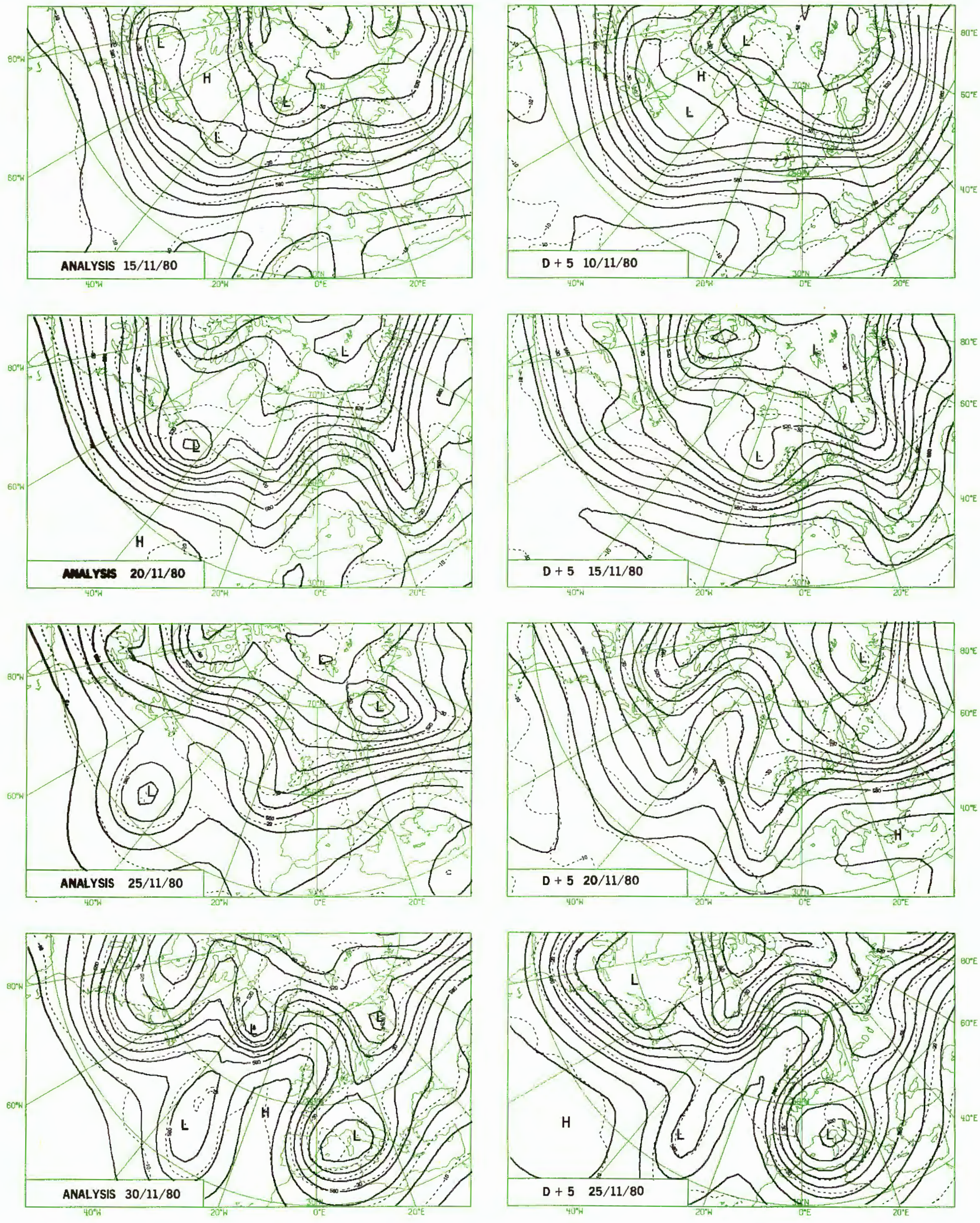


Fig. 10 The Centre's 500 mb analysis over the Atlantic-European area for 12 GMT, 15, 20, 25 and 30 November 1980, and 5-day forecast fields verifying at that time. 500 mb height contours (solid lines) are at 8 dkm intervals and 500 mb temperature (dashed lines) at 5 K intervals.

Administration Department

Structure

During 1980, as a result of the decision taken by the Council at its 11th Session (April 1980), the Administration Department and the Office of the Financial Comptroller were reorganised. This reorganisation was based on a detailed proposal of the Director. Organigrams of the old and new sections are shown below in Fig. 11.

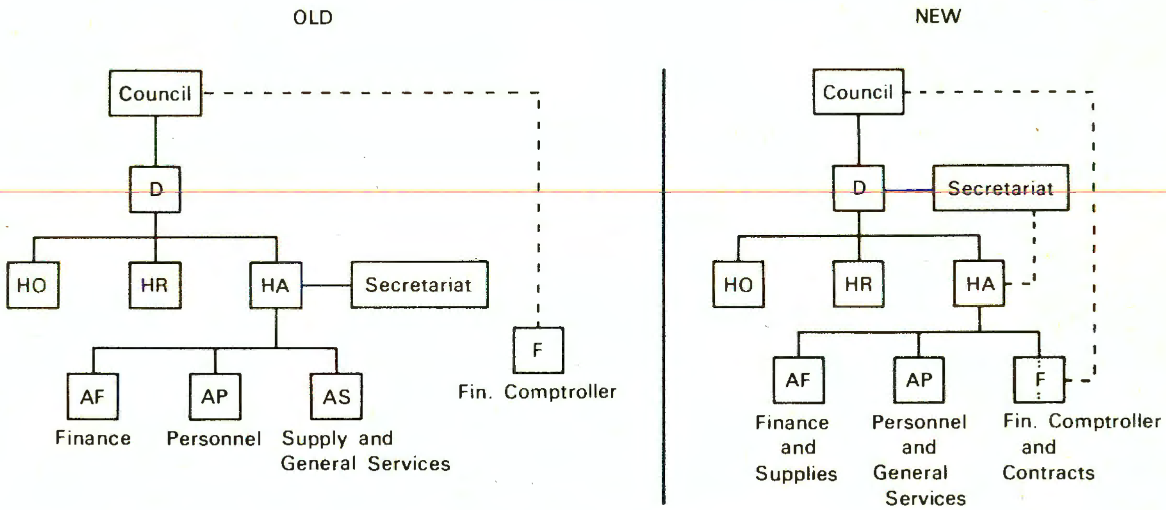


Fig. 11 Old and new organigrams of the Administration Department

With the arrival of the new Head of Administration, Mr. Hansjoachim Hartwig, implementation of part of the proposed reorganisation - the duties of the Finance and Supplies Section and those of the Financial Comptroller - began in September.

The other proposed section, Personnel and General Services, will be formally set up as soon as the new Head of Section is appointed.

Ceiling of Expenditure

As its 12th Session held on 20 - 21 November 1980, the Council adopted the new ceiling of expenditure for the years 1981 to 1984, and determined that the amount of Member States' contributions to be paid during that period should not exceed £26,000,050.

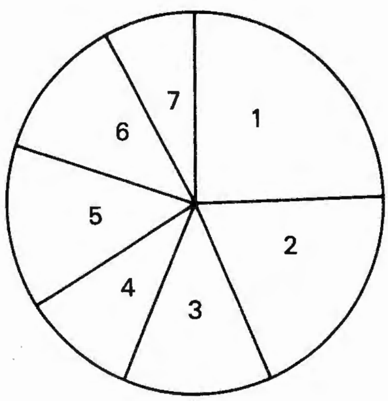
For the years 1981 to 1983, the adopted ceiling of expenditure to be covered by the Member States' contributions amounts to £19,398,300; this includes an increase of £770,700 (+ 4.14%) over the ceiling already approved by the Council at its 10th Session for the same period. The increase in the estimated ceiling of expenditure to be covered by the Member States' contributions is attributable for the most part to inflation and salary increases.

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

Scale of Contributions

The estimated Member States' contributions towards the 1980 Budget amounted to £5,671,000. 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.

Fig. 12 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	

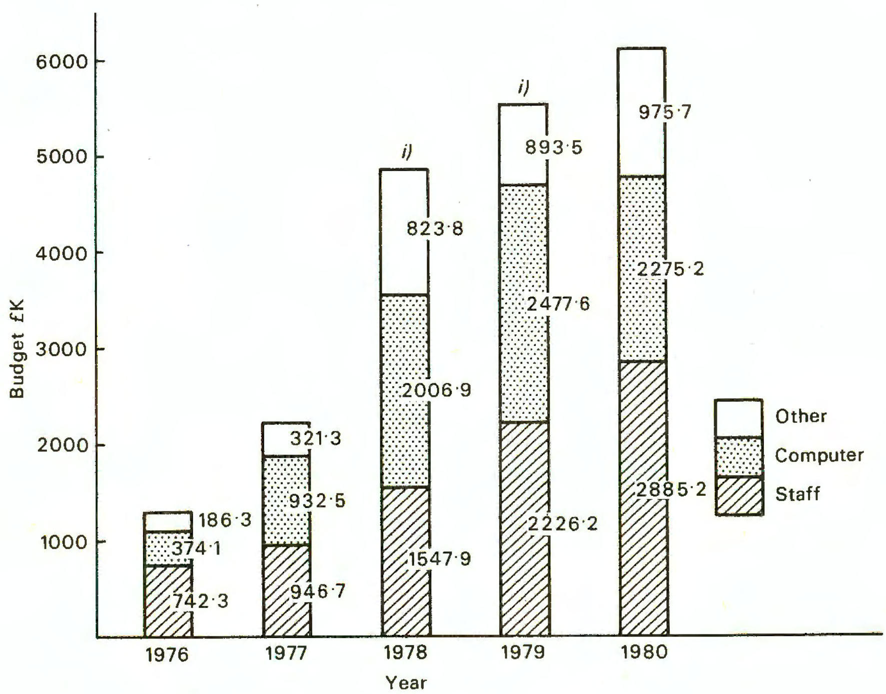
Fig. 12 Geographical and percentage distribution of Member States' contributions, 1979 - 1981

Budget

The Centre's 1980 Budget was adopted by the Council at its 10th Session (7 - 8 November 1979). The approved total expenditure and revenue for the year 1980 was £5,878,000 (net of Centre Tax) - an increase of 2.18% over the estimated 1979 total Budget of the Centre. The increase in expenditure over the previous year's Budget was due, inter alia, to adjustments in remuneration and recruitment of new staff members, higher costs for the use and maintenance of the computer system and the inflationary process affecting operating expenditure. The expenditure was mainly covered by the Member States' contributions to which were added the proceeds of taxation, staff contributions to the Pension Fund, and other miscellaneous revenue, e.g. tax refunds and bank interest.

During 1980, the financial needs of the Centre were mainly related to operating expenditure, of which staff remuneration and computer costs constituted the major part.

Fig. 13 shows the total expenditure during the years 1976 to 1980 for staff, computer equipment and other expenditure.



i) other expenditure includes furnishing of new headquarters

Fig. 13 Total expenditure on staff, computer equipment and other items over the years 1976 to 1980.

Staffing

The table of staff requirements for 1980 contained 145 posts. However, as a result of the Review of the Administration Department, three posts were suppressed. At 31 December 1980, there were 137 staff members and 5 visiting scientists/ consultants at the Centre, leaving 8 vacant posts at the end of the year.

Fig. 14 shows the number of staff employed against the number of authorised posts for the years 1976 to 1980, whilst Fig. 15 shows the growth of staff with respect to each Department.

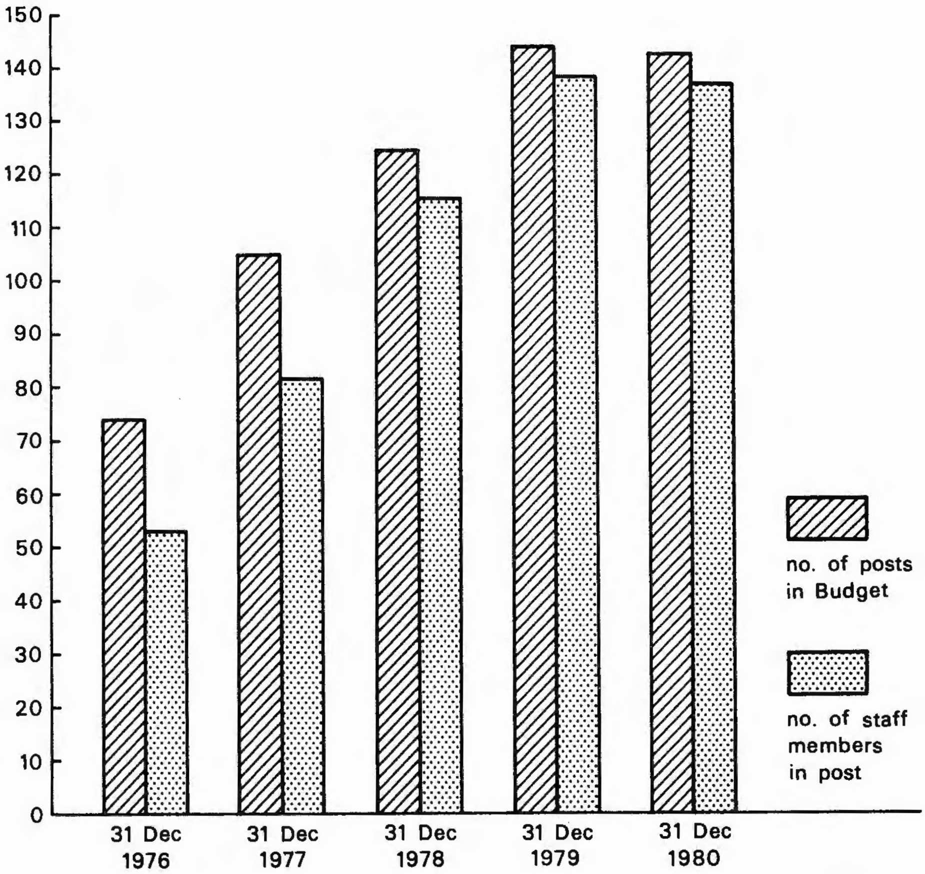


Fig. 14 Total of authorised posts and staff employed over the years 1976 to 1980

The Centre has been able to improve the balance of the geographical distribution of the A and L grade staff when recruiting new members. These efforts will continue. By 31 December 1980, nationals of 14 Member States were represented among the Centre's A and L grade staff. Fig. 16 shows the geographical distribution, together with a table showing the actual percentages. Table 6 shows staffing at 31 December 1980.

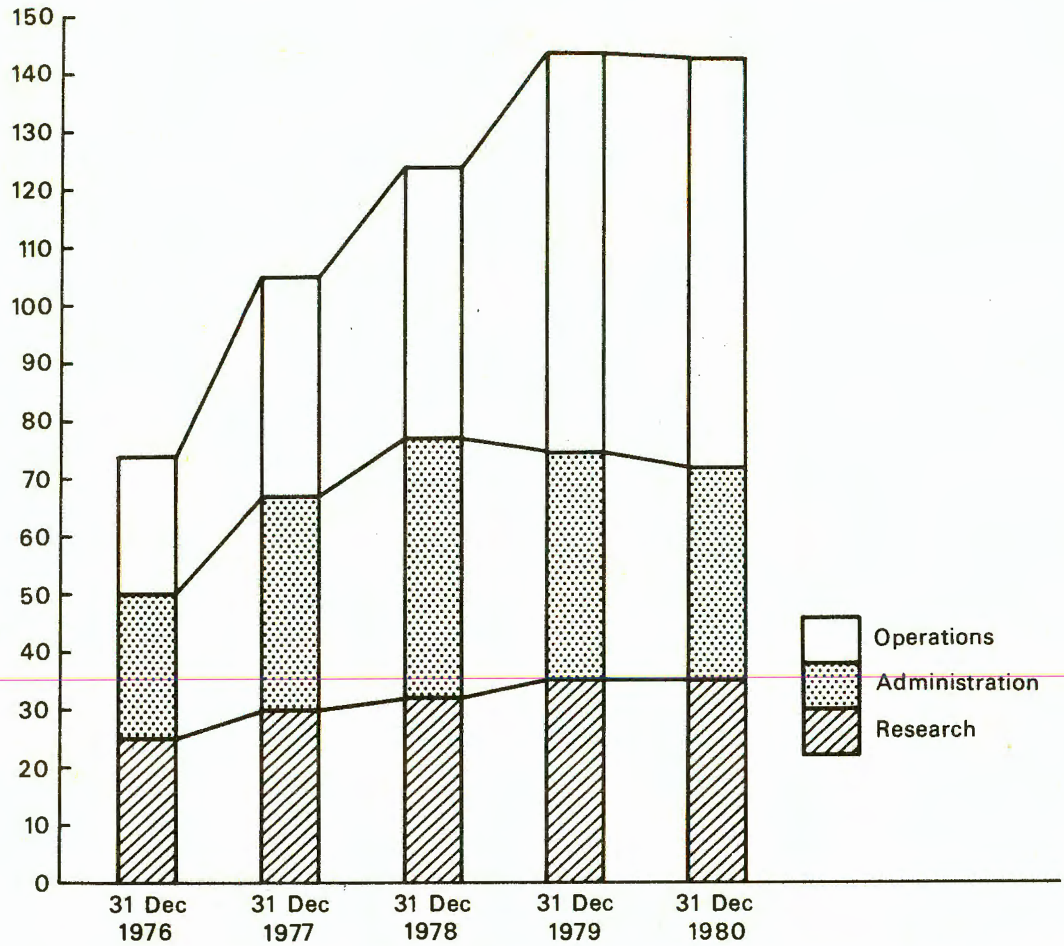


Fig. 15 Distribution of staff between departments over the years 1976 to 1980

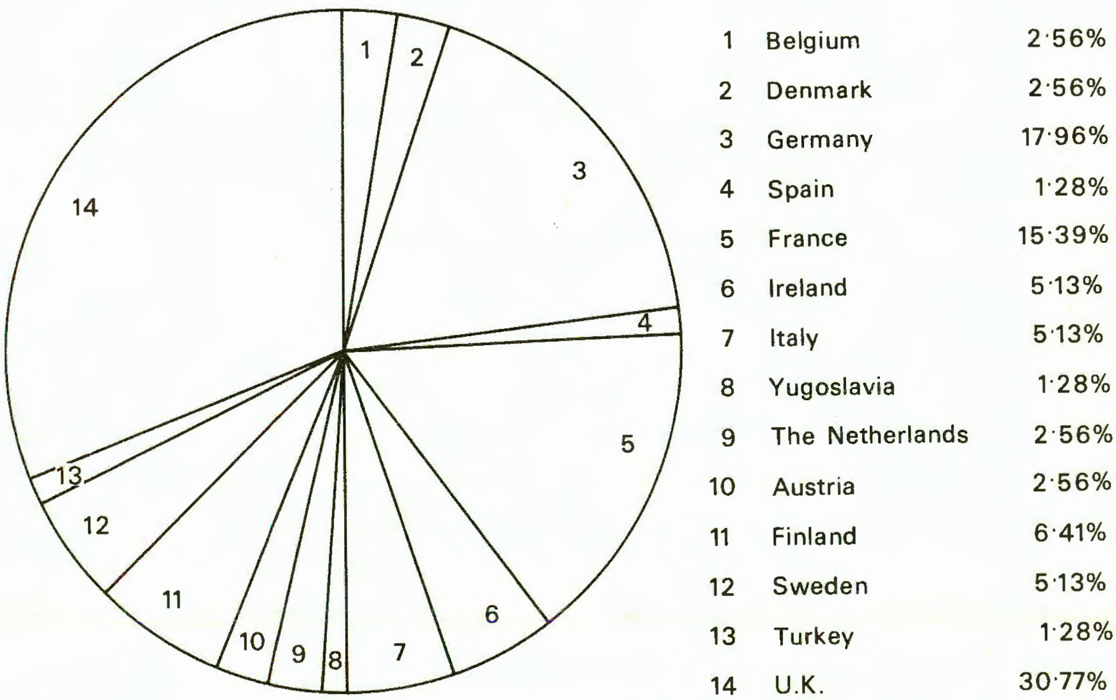


Fig. 16 Geographical and percentage distribution of A and L grade staff at 31 December 1980

Table 6. **Staff at 31 December 1980**

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

Distribution of staff by grade and nation

	*hg	A	B	C	L	TOTAL
Belgium		2				2
Denmark		2				2
Germany		13	2		1	16
Spain		1				1
France	1	9	3		1	14
Greece						
Ireland		4	1			5
Italy		4	1			5
Yugoslavia		1	1			2
The Netherlands		2	3			5
Austria		2	1			3
Portugal						
Switzerland						
Finland		5	1			6
Sweden		4				4
Turkey		1				1
United Kingdom		25	41	5		71
TOTALS	1	75	54	5	2	137

* Hors grade

Five visiting scientists/consultants were also employed by ECMWF at 31 December 1980

European School

The European School, which opened in September 1978 in Culham, Oxfordshire, has given great satisfaction as to the type and standard of education it provides. The Headmaster of the School continued his policy of accepting children of staff of the Centre; by 31 December 1980, 28 of these children were attending and it is expected that this number will increase still further.

Social Security

The subject of exemption from compulsory contributions to the UK Social Security Scheme for United Kingdom nationals remains outstanding. It is, however, the wish of both the Centre and the UK Government that a satisfactory agreement be reached during 1981.

The position with regard to the Social Security schemes applicable in the other Member States is being examined by the Administration Department in an effort to provide all the Centre's staff members with information on how they may be affected by the arrangements in force.

Coordinated Organisations

The Centre still has not been admitted to the Co-ordinated Organisations. Representatives of the Secretaries General of the Coordinated Organisations visited the Centre in April and December and discussions with the Secretaries General and the national delegations are continuing.

Security

The Centre's security requirements were reappraised during 1980 with the result that in 1981 the Centre will only employ a security guard from Mondays to Fridays during the period 08.00 to 20.00 hours. The more vulnerable areas containing operational plant and equipment have been shielded using steel mesh fencing and window screens. Access to the grounds by vehicles after office hours will be controlled by a security barrier.

Site Support Management

A market survey was undertaken during 1980 resulting in an Invitation to Tender being issued to select the services of a company capable of undertaking the Centre's site support services directly or managed by them through sub-contractors.

The Centre eventually awarded the planned maintenance contract to the incumbent contractor and concluded that it was more economical to continue to manage the general maintenance contracts from within the Centre's Administration Department.

Grounds and Buildings

In order to relieve car parking congestion, the Centre extended its car parking facilities by some 20 additional parking spaces.

Due to the high ambient temperatures experienced in the Concourse of the Conference Block, a contract was placed to improve the ventilation in this area.

Transport

The Centre was fortunate enough to win a British Leyland Mini City car in a draw held by one of its suppliers. The vehicle has been added to the Centre's transport pool and is now in daily use.

Education

Annual Seminar

This year's seminar took place during the week 15 - 19 September and was entitled 'Data Assimilation Methods'. Thirty-seven meteorologists from 13 Member States participated. The proceedings will be published in January 1981.

The following scientists were invited to give lectures:

Dr. R. Daley, National Centre for Atmospheric Research, USA

Dr. M. Ghil, Courant Institute of Mathematical Sciences, USA

Dr. N. Gustafsson, Swedish Meteorological and Hydrological Institute, Sweden

Dr. P. Julian, National Center for Atmospheric Research, USA

Dr. M. Kanamitsu, Japan Meteorological Agency, Japan

Dr. P. Morel, Centre National d'Etudes Spatiales, France

The subjects covered were:

Objective analysis

Initialization procedures

Normal mode initialization

Four-dimensional data assimilation

Sequential data assimilation theory

Operational data assimilation with FGGE data

Meteorological Training Course

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

A.	Basic dynamic meteorology	(6 May to 30 May)
B1.	Theoretical aspects of the ECMWF forecasting system	(2 June to 13 June)
B2	Practical aspects of the ECMWF forecasting system	(16 June - 27 June)

In total, the course was attended by 20 meteorologists from 10 Member States. The participants were very pleased with part A and found B1 and B2 to be satisfactory. For next year B1 and B2 will be slightly revised, while Part A will be kept in its present form. 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.

The Operations Department was also responsible for conducting a two week section of the course, namely the part oriented towards the practical application of the Centre's forecasting system. Laboratory sessions, in which the Centre's operational data bases were used to display and make use of forecast results, were included in this section of the course.

Computer Training Courses

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

Introduction to use of the ECMWF Computing facilities	17 - 21 March and 6 - 10 October
Advanced use of the CRAY-1	24 - 28 March and 13 - 17 October
Advanced use of the CYBER	27 - 31 October

The total number attending (often more than one of the courses) was 53 from 10 different Member States, and 19 Centre staff. In addition, two days' instruction on how to run simple jobs on the ECMWF computer system were given as part of the ECMWF Meteorological Training Course.

Workshops

Two workshops were held in the course of the year, one on the 'Diagnostics of diabatic processes' held on 23 - 25 April 1980, the proceedings of which have been distributed, and the second on 'Radiation and cloud radiation interaction in numerical models' held on 15 - 17 October 1980. The proceedings will be published in Spring 1981.

Seminars

In addition to the above, a number of seminars on subjects related to the work of the Research Department were given for ECMWF staff throughout the year. Twenty-one seminars were given by consultants or scientists visiting the Centre, and nine by ECMWF staff members.

The Council and its Committees

Council

The Council met twice in the course of 1980, for its 11th and 12th Sessions, held on 10 - 11 April and 20 - 21 November, respectively.

The representatives of the Member States at these Sessions were:

State	Delegate	Session
President (Ireland)	Mr. Rohan	11 and 12
Belgium	Mr. Sneyers	11 and 12
	Mr. Deloz	11
Denmark	Mr. Asmussen	11 and 12
	Mr. Nielsen	11 and 12
Germany	Mr. Lingelbach	11 and 12
	Mr. Schulze	11 and 12
France	Mr. Gosset	11 and 12
	Miss Martin-Sané	11
	Mr. Alt	12
Greece	Mr. Bassiakos	11 and 12
Ireland	Mr. Linehan	11 and 12
Italy	Mr. Zancla	11 and 12
	Mr. Mariani	11 and 12
Yugoslavia	Mr. Vasic	11
	Mr. Mesinger	12
The Netherlands	Mr. Bijvoet	12
	Mr. Voerman	11 and 12
Austria	Mr. Cehak	11 and 12
Portugal	Mr. da Costa Carvalho	11 and 12
	Mr. Mendes-Victor	12
Switzerland	Mr. Simmen	12
Finland	Mr. Huovila	11
	Mr. Jatila	12
	Mr. Panaanen	12
Sweden	Mr. Ag	11
	Mr. Lönnqvist	11 and 12
	Mr. Andersson	12
United Kingdom	Sir John Mason	11 and 12
	Mr. Day	11 and 12
WMO Observer	Mr. Weiss	11
	Mr. Schneider	12

Following the conclusion of a Cooperation Agreement between the Government of Iceland and the Centre, on 20 November, Mr. H. Sigtryggsson, Director of the Icelandic Meteorological Service, was invited to attend the 12th Council Session as an observer. Under the terms of the Co-operation Agreement, this will be a permanent practice in future.

At its 12th Session also, the Council elected Professor E. Lingelbach (Germany), to succeed Dr. P.K. Rohan as its President and Dr. L.A. Mendes-Victor (Portugal) as its Vice-President, both for a one-year term.

Finance Committee

The Finance Committee met three times in the course of 1980, for its 21st, 22nd and 23rd Sessions, held on 19 - 21 January, 22 - 25 July, and 16 - 18 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 1980 was as follows:

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

Germany
France
Italy
United Kingdom

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

Belgium
Portugal
Sweden

At the 12th Session of the Council it was noted that these three would continue for a second term of office of one year.

At its 23rd Session in September, the Finance Committee re-elected Mr. Wrany (Germany) and Mr. Deloz (Belgium) as Chairman and Vice-Chairman for a further year of office.

Scientific Advisory Committee

The 8th Session of the Scientific Advisory Committee took place on 22 - 23 May 1980.

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

Dr. R. Bates - Chairman	Ireland
Dr. E. Holopainen - Vice Chairman	Finland
Mr. F. Bushby	United Kingdom
Mr. S. Palmieri	Italy
Dr. E. Eliasen	Denmark
Dr. K. Hasselmann	Germany
Dr. C.J.E. Schuurmans	The Netherlands
Dr. J. van Isacker	Belgium
Dr. F. Mesinger	Yugoslavia
Dr. H. Reiser	Germany
Dr. R. Sadourny	France
Dr. H. Sundqvist	Sweden
Dr. B. Döös	WMO Observer

At the 12th Session of the Council in November 1980, Mr. Bushby was reappointed for a second term of four years and the two other outgoing members, Dr. Holopainen and Mr. Palmieri, were replaced by Dr. B. Hoskins (United Kingdom) and Dr. J. Peixoto (Portugal) for a first term of four years.

The Scientific Advisory Committee, at its 8th Session, endorsed the research strategy of the Centre for the four-year period 1981 to 1984, aimed at improving the quality and range of the Centre's forecasts.

Technical Advisory Committee

The Technical Advisory Committee held its 2nd Session on 3 - 6 June 1980.

All Member States are members of the Technical Advisory Committee. The representatives of each Member State in 1980 were:

Chairman:	J. Lepas	France
Vice-Chairman:	W. Wann	Ireland
	W. Struylaert	Belgium
	E. Busch	Denmark
	W. Buschner	Germany
	B. Orfila	Spain
	G. Barbournakis	Greece
	G. de Florio	Italy
	Z. Butigan	Yugoslavia
	A. Baede	The Netherlands

G. Wihl	Austria
S. Cristina	Portugal
R. Berggren	Finland
L. Moen	Sweden
M. Haug	Switzerland
Director General	Turkey
D. Johnson	United Kingdom

The Committee elected J. Lepas (France) Acting Chairman (previously elected Vice-Chairman in 1979) as Chairman, and W. Wann (Ireland) as Vice-Chairman at the session of the Committee in June.

The Committee made several recommendations regarding, inter alia, the plans for the telecommunications network between the Centre and Member States and technical aspects of the Centre's Budget for 1981 and Programme of Activities for the years 1981-1984.

Annual Forecasters' Meeting

In the evaluation of the Centre's products, synoptic assessments by experienced bench forecasters using the products are of major importance. Their opinions reflect the views of the first level of practical users of the forecasts.

Accordingly, a meeting of forecasters is held immediately before the Technical Advisory Committee Session. In 1980 this meeting was held on 2 - 3 June. Forecasters and experts with considerable synoptic experience who had studied the Centre's products, coming from 11 of the Member States, attended the meeting. Their conclusions were that:

- subjective evaluation of the Centre's forecasts for specific areas of interest examined in a conventional synoptic way showed that on average the mean of the quality score used was reached at between 4 and 5 days of the forecast, the scores for 500 mb tending to be somewhat better than at 1000 mb.

- as an average of relevant Member States evaluations, the percentage of "usable" or better for forecasts of the 500 mb geopotential field was 60% at 5 days and 40% at 6 days.

- the ECMWF products were on average the best available in the period 1 to 3 days.

These points were endorsed by the second session of the Technical Advisory Committee whose view was specifically that "the Centre's model outputs were on the average the most accurate available."

Member State Computing Representatives Meeting

Each Member State has nominated a Computing Representative whose role is to act as a focal and liaison point for aspects of the practical use of the Centre's computing system by Member States. The first meeting of Computer Representatives was held at the Centre from 21 to 23 October; representatives from 11 Member States attended.

International Meetings and Visits

Members of staff of the Centre have continued to attend international meetings related to the work of the Centre, and to make study visits (combined in some instances with giving lectures) as in past years.

The Centre was represented at the following meetings and conferences:

Networks 80 International Symposium on Data Communication and Computer Networks, Bombay, India (February)

'Deutsche Meteorologen Tagung', Berlin, Federal Republic of Germany (February)

Oceanology International 80 Conference, Brighton, UK (March)

International Symposium on Distributed Data Bases, Versailles, France (March)

2nd METEOSAT scientific users meeting, London, UK (March)

3rd IEEE Symposium on Mass Storage Systems, Denver, Colorado, USA (April)

ECODU 29 Conference, Berlin, Federal Republic of Germany (April)

12th Nordic Meteorological Meeting, Helsinki, Finland (May)

Symposium on Systems Performance and Early Results of Global Observing System for FGGE, Budapest, Hungary (June)

International Conference on Preliminary FGGE Data Analysis and Results, Bergen, Norway (June)

International Conference on Data Bases, Aberdeen, UK (July)

International Radiation Symposium of IAMAP, Ft. Collins, Colorado, USA (August)

Eurographics 80 Conference, Geneva, Switzerland (September)

Symposium on Probabilistic and Statistical Methods in Weather Forecasting, Nice, France (September)

International Conference on GATE, Kiev, USSR (September)

VIM33/ECODU30 Conferences, Manchester, UK (September)

Symposium on Mesoscale Numerical Modelling, GFDL, Princeton, USA (September - October)

XVIII Reunion Bienal de la Real Sociedad Espanola de Fisica y Quimica, Burgos, Spain (September - October)

European Working Group on Limited Area Modelling, Dublin, Ireland (October)

Working Group on Numerical Experimentation, Corvallis, Oregon, USA (October)

International Conference on Computer Communications, Atlanta, Georgia, USA (October)

Cray Seminar - 'Operational Service Experience using the CRAY in a Meteorological Environment', Stockholm, Sweden (November)

Cray Seminar - 'Operational Aspects of a Super Computer Installation', Helsinki, Finland (December)

CBS Extraordinary Session, Geneva, Switzerland (December)

In addition to the above Conferences, members of staff visited a number of universities and institutes. As well as visits to the national meteorological services and institutes of the Member States, these included visits to computer manufacturers, to NCAR in Boulder, Colorado:, NASA, Langley, USA; NWS and NMC Washington, USA; ANMRC, Melbourne, Australia and GFDL, Princeton, USA.

Lectures were given by members of staff at: the University of Bologna, Italy, GLAS, Greenbelt, Maryland, USA; Courant Institute of Mathematical Sciences, New York, USA; GFDL, Princeton, USA; University of Exeter, UK, NCAR, Boulder, Colorado, USA; University of Oregon, USA; University of Washington, Seattle, USA; University of Bonn, Germany; Imperial College, London, UK; Erice, Italy (Satellite Meteorology Course); Institute of Oceanographic Science, Godalming, UK; University of Graz, Austria; University of Vienna, Austria.

Attendance has also been maintained at meetings of the Co-ordinating Committees of Government Budget Experts, the Committee of Heads of Administration, and the Standing Committee of Staff Associations of the Co-ordinated Organisations, and at meetings of the various planning groups and committees of W.M.O.

Annex 1

ECMWF Publications 1980

Technical Reports

No. 17 The Response of a Global Barotropic Model to Forcing by Large-Scale Orography

No. 18 Confidence Limits for Verification and Energetic Studies

No. 19 A Low Order Barotropic Model on the Sphere with Orographic and Newtonian Forcing

No. 20 A Review of the Normal Mode Initialisation Method

No. 21 The Adjoint Equation Technique Applied to Meteorological Problems

No. 22 The Use of Empirical Methods for Mesoscale Pressure Forecasts

Workshop

Diagnostics of Diabatic Processes

Seminar

Data Assimilation Methods

EMCWF Newsletter

No. 1 February

No. 2 April

No. 3 June

No. 4 August

No. 5 October

No. 6 December

EMCWF Computer Bulletins

Introduction to CRAY-1 Vectorisation Techniques

Fortran Optimisation for the CYBER 175/300C

A Fortran Package to Identify the Time Consuming Parts of a Program

The ECMWF Software Library ECLIB

ECLIB Documentation

Intercom Procedures Library

Permanent File On-Line Space Control

Graphical Output on Microfilm

Technical Notes

User Guide to ECMWF's Integrated Data Base Access System

ECMWF's Meteorological Reports Data Base

A Description of Tropical Cyclones in ECMWF Forecasts

Case Studies of Precipitation Forecasts During the Period February-July 1980 by the ECMWF Operational Model

The Representation of Frontal Zone in the ECMWF Analysis and Forecasting System.

ECMWF Forecast Reports

Published monthly, containing routine verification and diagnostic statistics with topics of special interest.

No. 1	January
No. 2	February
No. 3	March
No. 4	April
No. 5	May
No. 7	July
No. 8	August
No. 9	October
No.10	November

Annex 2

Publications by Members of Staff

Bengtsson, L. On the use of a time sequence of surface pressures in 4-dimensional data assimilation. *Tellus*, *32*, pp. 189-197.

Bengtsson, L. Work of the European Centre for Medium Range Weather Forecasts. Proceedings of *Oceanology International '80* Conference, Brighton, June 1980.

Böttger, H. and Fraedrich, K. Disturbances in the wavenumber-frequency domain observed along 50°N. *Contributions to Atmospheric Physics*, *53*, pp. 90-105.

Geleyn, J.-F. and Preuss, H.J. Surface albedos derived from satellite data and their impact on forecast models. *Arch.Met.Geoph.Biokl.*, *Sec.A.29*, pp. 345-356.

Hollingsworth, A., Arpe, K., Tiedtke, M., Savijärvi, H. The performance of a medium range forecast model in winter - impact of physical parameterisations. *Mon.Wea.Rev.*, *108*, 1736-1773.

Hollingsworth, A. and Savijärvi, H. An experiment in Monte Carlo forecasting. Proceedings of the *WMO Symposium on Probabilistic and Statistical Methods in Weather Forecasting*, Nice, pp. 45-47.

Källén, E. and Wiin-Nielsen, A.C. Non-linear, low order interactions. *Tellus*, *32*, pp. 393-409.

Källén, E. A study of atmospheric variations on climatic and medium range time scales using bifurcation theory. Department of Meteorology, University of Stockholm, Sweden, (PhD thesis).

Königshofer, F. and Rakity, P. Network for Meteorological Applications. Proceedings of *'Network 80' CSI and IFIP TC6 Symposium*, Bombay, 4-8 February, pp. 97-108.

Newson, R. Institute stellen sich vor - European Centre for Medium Range Forecasts. *Promet*, *1/2* 1980 pp. 34-39.

Oriol, E.P. Verification of fluxes and energetics for ECMWF forecasts. Proceedings of *XVIII Reunión Bienal RSEFQ*, Burgos 1980, Libro F, communicación 10.13.

Savijärvi, H. Verification scores and systematic errors in early ECMWF operational forecasts. Proceedings of the *124th Nordic meteorological meeting*, Helsinki, pp. 179-194.

Savijärvi, H. Diagnostic studies on the balance requirements of the atmospheric large-scale flow. *Report 16*, Department of Meteorology, University of Helsinki. (PhD thesis).

Simmons, A.J. and Hoskins, B.J. Barotropic influences on the growth and decay of nonlinear baroclinic waves. *J.Atmos.Sci.*, *37*, 1679-1684.

Tibaldi, S. Cyclogenesis in the lee of orography and its numerical modelling, with special reference to the Alps. *Orographic effects in Planetary Flow*, GARP Publication Series No. 23, WMO, pp. 207-232.

Tibaldi, S., Buzzi, A., Malguzzi, P. Orographically induced cyclogenesis: analysis of numerical experiments. *Mon.Wea.Rev.*, *108*, 1302-1314.