The Met.Office

Annual Review

1993/94

The Met. Office Charter Standard for the Public

We aim to serve the public by providing -

Up-to-date weather information and forecasts

We will provide weather information and forecasts through radio and television, newspapers, telephone and facsimile services.

Weather warnings

We will issue warnings of severe weather through radio and television, and to emergency organisations such as the police and fire services. We will provide warnings of adverse road conditions to the police and to local and national radio. We will provide gale warnings and marine forecasts for radio.

Advice in emergencies

We will provide warnings of coastal flooding to the National Rivers Authority and the police. We will provide weather advice for the statutory authorities in environmental pollution emergencies that may arise, for example, from accidental release of toxic chemicals into the atmosphere.

Weather and climate information

We will maintain the National Meteorological Library and Archive at Bracknell that you may visit free of charge, and we will develop low-cost publications containing basic weather and climate information for schools and the general public.

To measure how well we are doing -

We will set performance targets and publish our achievements against them. We will monitor our forecasts, measure their accuracy and ask you in public surveys, conducted by independent consultants, for your opinions.

Our performance targets set standards for quality of service, accuracy and increases in efficiency. They are reviewed each year and our performance against them is published in the Annual Report and Accounts. Those connected with our services to the public are also published on a separate leaflet available free of charge from the Met. Office or our Weather Centres. Our performance against targets for 1993/94 are summarised in the Public Services section of this Review.

You can contact the Enquiries Office at Bracknell on the number on the back page, or leave a recorded message outside office hours. You can ask for leaflets giving details of our services, including where you can hear the latest forecast on radio or television. Details of our public services are published in programme magazines, newspapers and in telephone directories under 'Weather'.

Should you have a complaint, please telephone the Enquiries Office or, better still, write in. We want to hear your views and learn whether you are satisfied with the services we provide. We welcome your opinions and criticisms and will react positively to them. We aim to respond to a complaint within five working days of its receipt, or at least provide you with an acknowledgement and an estimate of when a full reply may be expected.

ISBN 0 86180 310 8

Designed, produced and published by Marketing Communications,
The Met. Office, London Road, Bracknell RG12 2SZ

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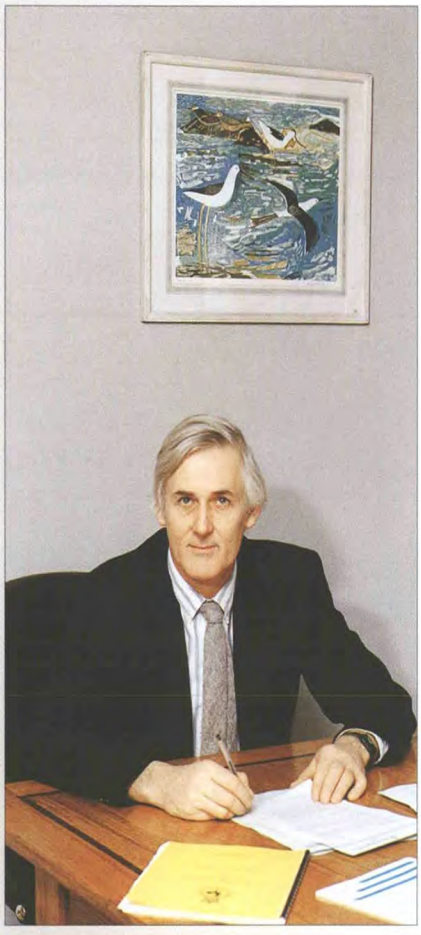
Foreword from the Chief Executive



Once again, it is a pleasure to report to our owners, customers, partners and staff that the Met. Office has had a successful year. We made substantial progress towards our scientific and technical goals, achieved our primary financial targets and steadily improved our efficiency. The result has been a continued growth in our customers' satisfaction with our services.

The three main reasons for this success are our progressive scientific and technological advances, our staff's adaptability to change and our determined efforts to strengthen international co-operation.

All this has been a particularly remarkable achievement during a year of considerable uncertainty, in which the Government has been deliberating over the administrative framework of the Office, and our budget, running costs and staff pay have been affected by restrictions in public spending and adverse fluctuations in exchange rates.

We can also report a growing contribution by our commercial customers to financing the Office's core costs, with an increase in revenue of 8% over last year. TV weather services in the UK and overseas are still the mainstay of our revenues, but there was also significant growth in offshore, land transport and water authority business and in the use of dial-up fax services for mass markets.

One element of our commercial services is to provide our products and data on a fair basis to the private sector and the Met. Office's policy on this has been clarified in general during the year. A study of the implications of moving to Trading Fund status is now under way.

Science and technology

Our Unified Model for numerical weather prediction (NWP) and climate change has been undergoing extensive development since 1990, but during 1993 it really began to show its paces. Its accuracy for NWP now confirms the Met. Office as one of the leading world forecast centres. The version for prediction of climate is being improved by employing observations made by the Meteorological Research Flight's C-130 aircraft to increase the realism with which atmospheric processes are represented and by introducing better coupling between the atmosphere, oceans and sea-ice, which now also includes sea-ice dynamics. The new Cray-90 computer system installed in March 1994 helped meet growing demands for this work.

Our Unified Model's remarkable versatility enables us to develop special versions for local forecasts all over the world. These local versions are also being used on smaller workstations by our defence customers, and by research groups in the UK and abroad with whom we collaborate.

However, to improve the accuracy of numerical modelling still further also requires long-term improvements to the quality and quantity of observational data. Remarkably, the broad direction for this was set out as long ago as 1978 by Sir John Mason in a far-sighted article in the Meteorological Magazine, and even now continues with our collaboration in EUMETSAT and the COST-75 group, who are planning as far ahead as the year 2010. The Met. Office was among the first in the world to improve its weather forecasts by 'assimilating' measurements from the European Earth Resources Satellite (ERS-1) into the numerical model, and last year saw further progress towards better integration of observations from weather radar, satellites and surface stations. This process is helping the notable reliability of our tropical cyclone forecasts, which are making a significant contribution to the UN's International Decade for Natural Disaster Reduction.

Information processing and communications systems are another vital element of our operation. A logical consequence of the convergence of technology in these areas was the integration of our telecommunications and computing branches during the year.

Professor Julian Hunt Chief Executive

We continued to develop our screen-based meteorological information systems, MIST and ODS. These are designed for commercial, defence and aviation use, and have been extended to serve our outstations, TV and radio studios and a wide range of customers.

Staff

In April 1993 I was delegated additional powers on personnel matters from the Permanent Under Secretary of State, MOD, and on 1 April 1994, the Office assumed responsibility for negotiations on pay and conditions of service. To prepare for this, the Office gave notice to the Trade Unions that we would withdraw from all central pay agreements; negotiations started in early 1994. Current plans include the introduction of a new pay and grading system, designed to meet the need to recruit and retain staff of wide-ranging disciplines and abilities in a cost-effective manner. Pay-bill modelling and a job evaluation scheme were progressed during the year and the key concepts of the new system have been developed.

Since we became an executive agency, staff at all levels are taking initiatives in quality improvement, involving teamwork and independent decision-taking. They have changed their work practices, the way in which they organise themselves, how they analyse problems and how they relate to their customers — externally and within the Office. Modern quality management methods are also improving our internal communications.

International

The global scale of weather and climate, and the fact that no organisation can prosper in isolation, means that a vital element of the Met. Office's strategy has to be to improve collaboration with other meteorological services, research organisations and industry. This was the theme of the first and very successful — European Conference on Applied Meteorology, which we organised in conjunction with 30 other organisations at the University of Oxford in September 1993.

On a wider stage, the Met. Office has had a prominent role at the World Meteorological Organization (WMO), working to establish a new framework for a data exchange agreement. Its purpose is to balance the conflicting objectives of close collaboration and mutual support between National Met. Services, while allowing for the rights of commercial customers to purchase meteorological services from any country that supplies them.

The Office is particularly proud that the United Nations awarded the UN medal to our members of the Mobile Met. Unit for their services in Bosnia this year. This is the first time any member of the Met. Office has received this medal. As well as for Bosnia, we provided specialised forecasts and meteorological advice for the UK and United Nations defence forces in the Balkans, Turkey and Iraq.

Closer liaison with and feedback from the Civil Aviation Authority (CAA) has been a special feature of our services to international aviation. The nine major airlines which are served directly from the Met. Office, and the other twenty or more indirectly served, remain loyal customers for Bracknell's products.

The benefits obtained from international collaboration are also obvious in our research work, in fundamental meteorology, forecasting and studies of climate change, including, significantly, contributions which have led to some of the improvements in our Unified Model. This traffic is two-way; the Met. Office has also shared its research with other institutions, many of whom are using our data, computer models and algorithms.

Governments around the world, including those seeking to commercialise their meteorological services, recognise that these collaborative ventures are highly cost-effective. Of course, meteorologists everywhere know that without this interchange of information, providing forecast, climate and environmental services would be impossible, as would their continued improvement. I and my colleagues in the Met. Office will do all we can to ensure the continuation of this 140-year-old tradition.

The International Dimension

As a science and a source of effective services Meteorology knows no boundaries. It demands an international stage and close collaboration between nations. This comes about through the World Meteorological Organization which now has over 170 member countries.

Collaboration takes many forms but is geared mainly to the capture and exchange of data, products and services particularly between National Meteorological Services. To ensure efficiency and effectiveness it is most important to agree what will be exchanged, when and by what means. It is also important to coordinate activities as far as possible so that all the services required by WMO Members are available, and overlap is minimised.

Voluntary Co-operation programme

The UK Met. Office is a significant donor to the WMO Voluntary Co-operation Programme, which helps developing countries improve their meteorological infrastructure and services. This year we donated Meteorological Data Distribution Systems (MDDs) to Namibia and others have been procured for Seychelles, Mali, Gambia, Jordan, Nigeria, Tanzania and Zambia, which will be installed early in 1994/95. This project is carried out in partnership with the Natural Resources Institute, the scientific arm of the Overseas Development Administration. An MDD has also been procured for the African Centre of Meteorological Applications for Development (ACMAD) in Niger.

The Met. Office has continued its programme of donating climate computers (CLICOM), and sent a satellite receiving station to The Gambia.

This year a total of 34 students from 19 countries were supported on wide range of training courses. Funds were also given to Regional Meteorological Training Centres in developing countries to train local staff and help them develop high-quality lecture materials using desk-top publishing.

Commonwealth Conference

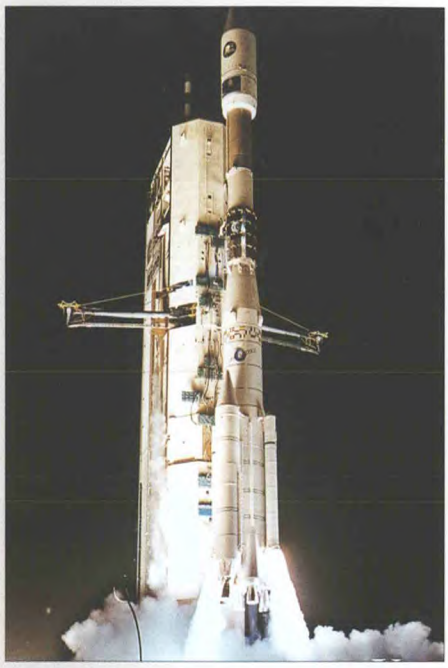
In July, the Met. Office hosted the Commonwealth Meteorologists Conference, attended by the heads of 23 National Met. Services. A broad range of issues was discussed in an informal atmosphere over four days of conference. The meeting statement highlighted a number of new priorities such as the role of NMSs in capacity building and the International Decade for Natural Disaster Reduction.

European collaboration

The Office contributes to the European space programme through EUMETSAT which provides the Meteosat geostationary satellite over the equator at 0° W, and is presently providing backup for a failed US satellite. The Meteosat Second Generation Programme was also initiated this year, to launch the first of an improved series of geostationary satellites in 2000.

The year has been marked by discussions on more systematic co-ordination of investment, planning and development of meteorology among the members of the European Union. The National Meteorological Services of western Europe have now begun to study whether joint action might improve the cost-effectiveness of their investment in observation and telecommunications systems.

The first example of this approach is the European Climate Support Network (ECSN), formed in 1992, to promote more-effective collaboration on climate



EUMETSAT's Meteosat 6 was launched from Kourou in French Guiana on 20th November 1993 at 0117 UTC (GMT).

Met. Office forecasters went to Niger to carry out on-the-job training.

monitoring, research and prediction in Europe. It is now beginning work on projects which include high-resolution climate simulation, regional European climate modelling, various climate database projects and a European climate assessment. A less formal network has been set up for research into short-range numerical weather forecasting, which is expected to progress to more extensive links between the forecasting centres within Europe.

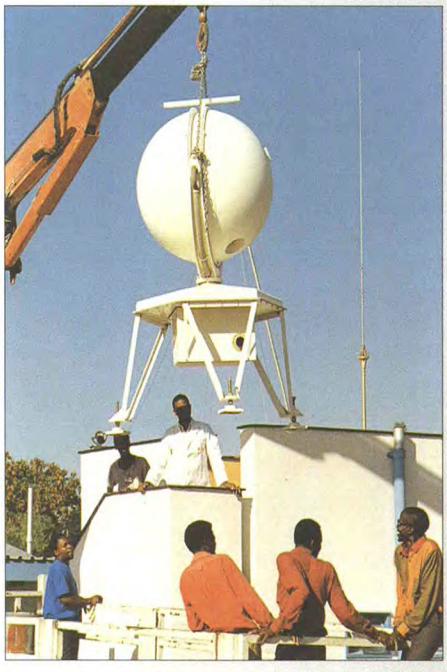
ECOMET

1993 saw considerable effort applied by Met. Office staff and sixteen other European Met. Services to advance the ECOMET concept. The aims of ECOMET are to improve the availability of meteorological information throughout Europe, for commercial use by private or public operators, while maintaining the essential exchange of basic information for non-commercial use. Success of this proposal should ensure that commercial operations provide financial returns to support the expensive European infrastructure. However, it requires permission from European Commission, as it implies some exemptions from European competition law. A revised submission to the Commission was tabled in December.

European Conference

September saw the First European Conference on Applications of Meteorology in Oxford, chaired by Professor Julian Hunt, Chief Executive. A total of 270 delegates from over 20 countries attended lectures given by research workers, representatives from European National Met. Services, the private sector and their customers. The main papers will be published in the new European-wide journal, *Meteorological Applications.*

There was lively debate on topics ranging from the economic benefits of weather forecasts to forecasting techniques, and from new applications for weather forecasts to the needs of users. All parties were able to exchange ideas on applications and benefits in the expanding world of meteorology. Discussions arising from this conference are continuing, with emphasis on climate and seasonal forecasting in the framework of the European Climate Support Network (ECSN) and the European Centre for Medium-range Weather Forecasting (ECMWF). The event was a great success and a second conference will be held in Toulouse in September 1995.



Met. Office staff helped Botswana move a wind-finding radar (which we donated in 1987) to a new site 300 miles away.

Commercial Collaboration

Our commercial activities overseas continued to expand through bilateral agreements with other NMSs. As one example, the UK Met. Office has now set up an office in Singapore in co-operation with the Singapore Met. Service and with concurrence from other NMSs in the area.

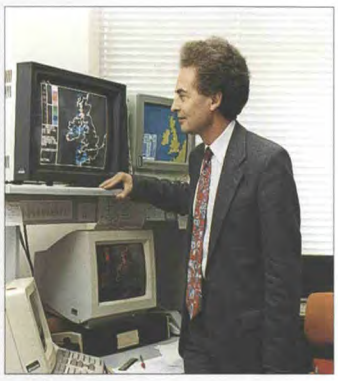
Memoranda of Understanding already exist with China, New Zealand, Norway, and Sweden for data exchange and provision of specific services, and we plan to continue to work bilaterally with NMSs and the private sector, to develop meteorological services worldwide.

Our consultancy and training services continue to be taken up by NMSs planning to introduce commercial services; Switzerland and Austria received consultancy and training from us this year while staff from Hong Kong and Spain attended the Met. Office College at Shinfield Park for courses on commercial skills.

International Forecasting Unit

Our international services mostly rely on the newly created 'International Forecasting Unit' (IFU), which has a commercial manager, is staffed by CFO forecasters, and is located in the Central Forecast Office (CFO). Here, it has the major benefit of access to all the global forecast data and a continuous global synoptic perspective.

Our Services



Public services

Public safety

1993 was the wettest for twenty-seven years in England and Wales, and as early as mid-October, the Highlands of Scotland experienced heavy snow, with Aberdeen recording the earliest date for snow lying for fifty-one years, on 15th October. Severe weather continued to affect the Highlands throughout the winter, which unfortunately led to a number of deaths among hill walkers and mountaineers despite forecasts and warnings issued by the Met. Office. The year ended with many rivers in southern England above danger level, culminating in the extensive flooding of the historic city of Chichester in West Sussex for several days.

This period of bad weather caused us to invoke many severe weather warnings which we issue to public and emergency services — as we are committed to do by our Charter Standard for the Public (see inside front cover).

About a third of the 16,000 loans from the Met. Office Library were to members of the public.

Severe weather warnings

Our early warnings to emergency organisations now include risk assessments, first introduced on a trial basis in the last quarter of 1992/93. They have been widely welcomed and are now incorporated as a permanent feature. Our performance standards for the emergency services are judged with a satisfaction survey, carried out annually. Last year, this continued to show a high degree of satisfaction with less than 3% expressing dissatisfaction. Our performance target was to achieve a satisfaction score of at least 80%; we achieved 79%.

Storm Tide Warning

On 28th January 1994 the morning high tides at Lowestoft and Felixstowe were the highest recorded for ten years, with the sole exception of those on 21st February 1993. One of our performance standards (agreed with the Ministry of Agriculture, Fisheries and Food — MAFF) is to issue warnings of these major surges to the National Rivers Authority (NRA) and police forces at least 12 hours in advance. This we achieved.

Improvements in the accuracy of surge forecasts in recent years have enabled us to improve warnings of negative surges, such as occurred around Christmas 1991, when the combination of a strong south-westerly wind and a deep depression caused unusually low water in the Strait of Dover. The expected magnitude of such reductions in tidal level is now included in warnings, and information on major surges can be issued up to 30 hours in advance.

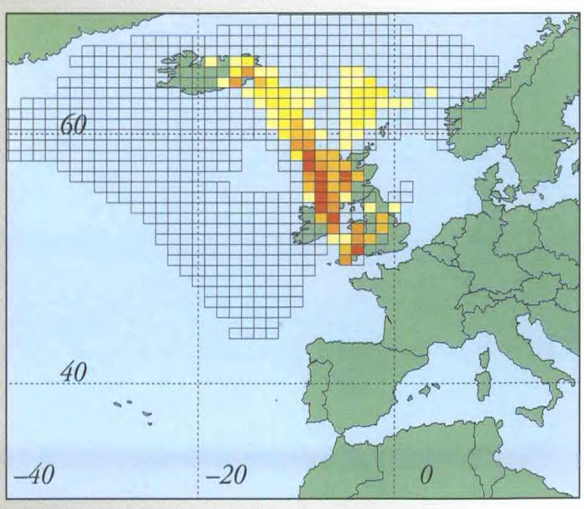
Shipping

The shipping forecast broadcast to ships at sea on Radio 4 is also set performance standards. Targets are based on the accuracy of gale warnings; in 1993/94 we exceeded these by achieving a success rate of 82% and a false alarm rate of 13%. The targets were a minimum of 80% and a maximum of 20% respectively.

Pollution Emergencies

The Met. Office's leading international capability in this area was recognised by our appointment, from 1st July 1993, as one of four Regional Specialised Meteorological Centres within the WMO for providing services in the event of international environmental emergencies; the others are Montreal, Toulouse and Washington. The past year has seen very significant progress in harmonising and refining procedures, models and services among these centres. The Met. Office's part in the National Response Plan is managed by Defence Services.

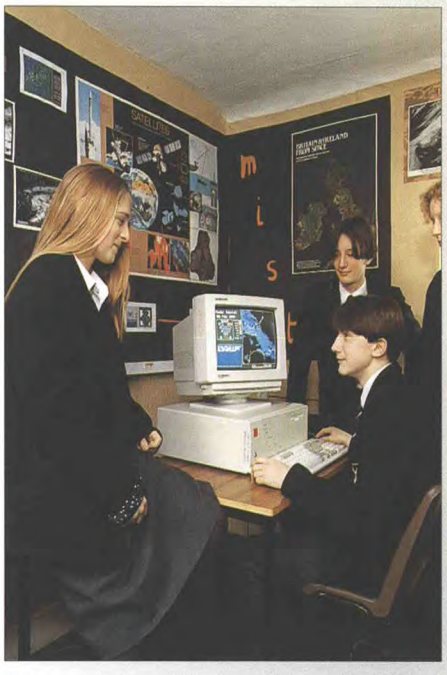
Radioactive releases are tracked by the Radioactive Incident Monitoring Network (RIMNET), Phase 2 of which became operational during March 1994. Output is



The pollution diagram service uses our Nuclear Accident Model (NAME), based on the long-range transport model we developed following the Chernobyl incident. The diagram shows the trajectory of a hypothetical event modelled by NAME.

Colin Flood, Director of Central Forecasting

On the east coast, surge height exceeded 1.5 metres from Cromer to Sheerness.



Wells Cathedral School purchased a MIST.

passed to the Department of the Environment along a dedicated BT line, installed by Siemens Plessey Controls Ltd. There, it is stored and displayed alongside gamma radiation measurements from RIMNET, to help assess where plumes of pollutants are likely to spread.

Providing and monitoring weather information and forecasts

Most of the familiar weather forecasts on TV and radio are provided commercially, which minimises the cost to taxpayers, takes full advantage of the latest presentation and production techniques and helps maintain the highest standards.

Our Charter requires us to set performance standards for the public forecasts and monitor them. Forecasts have been steadily improving over the years and this is reflected in the targets. Performance standards relate to both accuracy and customer satisfaction. Forecast accuracy is measured by comparing the forecast with what is observed, and last year we achieved 86%, exceeding our target of 84%.

Customer satisfaction is monitored through surveys conducted by independent consultants; in 1993/94 our target was 80% and we achieved a customer satisfaction score of 83%.

An important development during the year was the proposal by the Meteorological Committee to report on our public services periodically to ensure they continue to provide value for money. A pilot report was compiled by Baroness Platt and members of the Meteorological Committee, which led to some valuable advice. This monitoring will continue as part of the regular business of the Committee.

Public information

The National Meteorological Library and Archive continued to be very busy; a customer satisfaction survey revealed that 80% of respondents were satisfied with the service. As a result of a market testing exercise, a new automated library management system will be introduced.

The high-tech nature of modern forecasting is now being demonstrated to the public at shows such as Open Days at Defence Services stations, using a new mobile trailer display specially developed during the year for the purpose. The trailer is equipped with the most up-to-date computer graphics of weather information, fax terminals and satellite imagery, and has been well received at all the events.

Education

Education services continued to grow, with new products added to the award-winning MetFAX Education service. Over 8,000 of our resource packs for Key Stages 1 and 2 of the National Curriculum have now been sold and more wall charts and posters were produced.

In addition, this year we introduced a popular series of Basic Meteorological Courses for Teachers, designed around National Curriculum Attainment Targets for Key Stage 3 and 4. The courses will be repeated through 1994.

Over 7,500 enquiries were answered by the Education Service during 1993, many at little or no cost to the enquirers.

Enquiries and complaints

Enquiries and complaints are handled by the Enquiries Office at Bracknell (see back cover for details). In 1993, the Enquiries Office handled 5,613 enquiries, of which 329 were complaints, mostly associated with errors in forecasts.

Defence Services

As well as the continuing presence in Bosnia, the Mobile Meteorological Unit (MMU) supported operations in Gioia del Colle, Italy (Operation DENY Flight) and one at Incirlik in Turkey (Operation Warden). United Nations medals were awarded to two staff, Flight Lieutenant C. Robins RAFRO and Flying Officer B. Laing RAFVR, who served at Kiseljak. Nineteen Military Exercises in the UK and overseas were also supported.

In August 1993, the MMU established a small full-time HQ at RAF Benson and a unit in Germany. The task of the German unit is to support the Allied Rapid Reaction Corps (ARRC) HQ, the RAF Harrier force and Army Air Corps helicopters. The unit will be assisted by personnel from Germany and the USA.

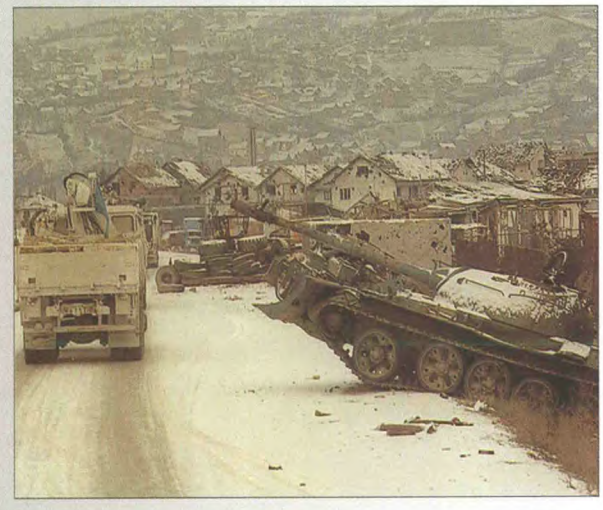
Options for change

Reorganisation in response to the military's annual Statements of Requirement for meteorological services resulted in the closure of five offices during the year. When the Options programme is fully implemented in 1995, there will have been a reduction in staff numbers of 64. However, the requirements of the Army have increased and a new Range meteorological office was opened in West Freugh, where a LORAN radiosonde has been installed for accurate forecasting of upper air conditions.

Operational and Tactical Decision Aids (ODA and TDA)

A number of ODAs have been issued during the year to assist forecasters to predict such things as runway icing, low-level wind flow, low cloud and fog. A computer-based airfield weather package is also being developed to allow rapid access to local climatology, topography and weather characteristics. A new acoustic prediction package, developed with the Department of Applied Acoustics at the University of Salford, allows forecasters to make better predictions of peak noise levels which can be overlaid on computer-generated maps of the locality.

The development of TDAs to provide tactical environmental advice to military commanders has continued with improvements to the current operational night illumination TDA, and the issue of a guide to forecasting for Forward Looking Infrared (FLIR) operations. Infrared temperature measurements taken at Boscombe Down were used in a preliminary assessment of a new background temperature model. Background temperature and thermal contrast are critical factors in the operation of FLIR systems as navigation aids for feature identification. The results suggest that the new model is capable of predictions which are more realistic than current operational models.



The MMU supported overseas military operations with two staff on rotation in Kiseljak, Bosnia (Operation Hamden).

With the increasing importance of multinational operations, it is essential that tactical meteorological advice is consistent, and we are contributing to a NATO Working Group to identify a recommended suite of tactical decision aids.

Defence Services Information Technology

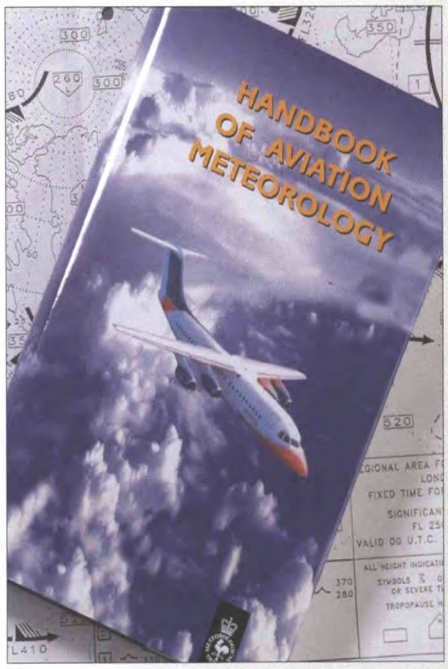
A significant outcome of an assessment of the way IT can support the MMU is a new prototype meteorological display system known as Mobile ODS. It is based on the successful Outstation Display System (ODS) now equipping all fixed forecasting offices. A prototype mobile system has been developed and purchased.

Detailed planning has started for supplying information for aircrew through the RAF's Automated Low-Flying Enquiry and Notification System (ALFENS) due to enter service during 1995.

All outstations are now fully equipped with personal computers for running specialised forecasting algorithms and a contract has been placed for the development and installation of a special version of MIST to support the armed forces in Northern Ireland.

Dr Jim Caughey, Director of Defence Services.

The new upper-wind system produces more-accurate wind forecasts for flight planning and leads to savings in fuel.



A revised and updated edition of the Handbook of Aviation Meteorology is now complete and will be published during 1994. It is widely used as a training manual and a new edition has been awaited by many meteorologists, aviation instructors and operators.

Aviation Services

International Services.

During November 1993 the Met. Office and the CAA hosted discussions at Bracknell on the next stages of World Area Forecast Systems (WAFS) planning for the ICAO WAFS Study Group.

One of the main points discussed was the introduction during 1994 of a new, high-resolution grid for global upper-wind and temperature information generated by Bracknell and Washington. Software developed by Bracknell will enable customers to interpolate winds to selected regular arrays of latitudes and longitudes, to ease derivation of leg winds.

Since April 1993 significant weather charts for the North Atlantic region have been produced by Bracknell using a workstation, developed for the future automation of global significant weather data. This has enabled us to produce high-quality, reliable computer graphics of the North Atlantic charts. Development will continue during 1994, and as a first stage it is expected that the European region and Europe to Asia (MID) region will also be generated at Bracknell.

Planning for the satellite communications distribution system (SADIS) service led in February 1994 to competitive bids being received for evaluation. The service is expected to start by the end of 1994, or early 1995 and will mark a significant milestone in satellite distribution of essential meteorological data for aviation.

National Services.

MetFAX, introduced last year, is now firmly established and valued by the general aviation community for providing meteorological information efficiently and conveniently.

Together with British Aerospace we have continued to refine the MIST software. The updated version, expected to be completed during 1994, will improve services for helicopter operations, and all other sectors of aviation. Services for General Aviation are operated commercially under a revenue sharing agreement with the Civil Aviation Authority (CAA).

New aeronautical codes for meteorological reports (METARs) and aerodrome forecasts (TAFs) were introduced on 1 July 1993. Despite significant differences between the new and old codes, the transfer went smoothly and all automated systems were reprogrammed on time. Some elements of the new codes are not welcomed by some users, so experts from ICAO and WMO will be meeting to agree final changes in the light of operators' comments.

Training

Arrangements have been made to hold a seminar at the Met. Office College for aeronautical forecasters in 1994 under the WMO training programme, similar to a successful one held during July 1992. The seminar will help forecasters understand numerical weather prediction (NWP) products and how to apply them for aviation.

During the summer of 1993, jointly with CAA International Services, we provided three week's specialised training in aeronautical meteorology to meteorologists from Romania. This will be repeated in 1994.

Commercial Services

1993/94 was another year of steady growth in revenue with an 8% increase on the previous year. Among the most successful sectors were Energy and the Media, with revenue increases greater than 20%.

An independent survey carried out during the year to assess the size of the global weather market estimated it to be of the order of £320m per annum of which the Met. Office has around a 5% share. A large part of the remainder is held by the US and Japanese private sector.

Throughout the UK, our commercial services are provided from 14 Met. Office Weather Centres, which are also engaged on tasks for the Public Met. Service (PMS), aviation and defence customers, as well as supplying observations. This arrangement has been analysed and found to be cost-effective. Staff at Weather Centres add local meteorological knowledge to the centrally generated forecast, and are familiar with local customers' needs. It is this responsiveness to clients' needs which helped The Weather Initiative (a Met. Office business unit) win a contract from Marks and Spencer this year, after a lengthy period of competitive comparisons.

Nevertheless, the efficiency and cost-effectiveness of the Weather Centre network is under constant scrutiny, in the light of changing workloads, new technology and an improving knowledge of customers' requirements. The advent of OPUS (see page 19) has also triggered a review of staffing levels which has identified some potential savings.

Television and Radio

It has been an eventful year for BBC services. Sadly, Bernard Davey retired from the BBC TV circuit on medical grounds, but the team has been expanded with Richard Edgar, Helen Young and David Lee.

During February 1994, we negotiated with BBC Five Live to provide a live weather service, with the presentation team led by the independent broadcaster Philip Eden. This service started on 28th March from a new Weather Centre constructed within BBC Broadcasting House.

BBC World Service TV (WSTV) expanded further with additional services into Africa and Canada. Further growth is expected as WSTV take on a service to Arabia and a significant increase in their European output.

Independent Weather Production's services to commercial television have continued to flourish with retention of the contract for the ITV National service, many UK regional services, and several TV weather services broadcast overseas by satellite. The unit has continued its programme of enhancing and updating its technology.

Phone and Fax Services

MetFAX Marine and Marinecall telephone services achieved significant growth. A new service offers callers the choice of latest coastal weather reports as well as traditional forecasts. A customer satisfaction survey carried out on MetFAX Marine returned very good results; 97% of customers were satisfied or very satisfied with presentation and reliability, 92% with accuracy.

In November the Weathercall Fax service was introduced to complement the existing Weathercall telephone service run by Telephone Information Services.

MIST has been used at sporting events such as Wimbledon, the PGA tournament, and Grand Prix racing at Silverstone.

MetFAX dial-up fax services, operated on our behalf by Vodata Ltd., and Telephone Information Services Ltd. (TIS), continued to rapidly grow. Satellite images were introduced early in the year after trials and consumer research, and have proved highly popular.

Bernard Herdan (left Met. Office Director of Commercial Services) and Malcolm Jessop (Managing Director of Telephone Information Services). TIS handled over 4 million calls from the public for weather forecasts last year.

On 11th January 1994, we celebrated 40 years of weather forecasting on BBC TV with all the surviving ex-TV Weathermen, including the very first, George Cowling, (seated centre).

MIST can use satellite links, or a cellular phone as demonstrated to His Royal Highness the Duke of York, when he took delivery of a system from the Met. Office and our parter British Aerospace.

MIST PC-to-PC System

The Meteorological Information Self-briefing Terminal, MIST is living up to its claim to be the PC weather information distribution system of the future. Clients range from Universities and schools, to the utilities, offshore oil companies, MOD and British Helicopters. The Ordnance Survey flying unit at Blackpool, said "MIST has been worth its weight in gold, it gives us an extra 10% of flying time and often saves our bacon in aborted missions and flying hour costs".

MIST can be used for briefings outdoors as it is portable, light, and easy to use.

Land Transport

OpenRoad had another excellent year with improved frost prediction accuracy — good guidance was given on 92% of occasions. New sensors were installed in Essex, Warwickshire, Derbyshire, Nottinghamshire and Bromley. The total number of forecast sites increased to 237 nationwide, representing nearly 42,000 individual forecasts issued during the season.

Offshore and Marine Services

In January 1994 we launched the Marine Weather Group, a new Business Unit for shipping and the offshore oil and gas industries, to provide climatological information, shiprouteing services (MetRoute), and the Offshore Forecast Centres in Bracknell, Aberdeen and Singapore.

Over the last year the Marine Weather Group launched a range of enhanced wave and wind forecasts. Innovations include incorporating ERS-1 satellite data into the wave model, to improve accuracy of sea and swell forecasts. Forecasters provide detailed time-sequence displays of graphical and tabular marine forecasts out to five days. New MIST programs have been developed which allow offshore users to identify the timing of weather windows and plan efficiently around operational thresholds.

As mentioned on page 7, we opened an office in Singapore in November 1993, in association with Wimpey Environmental Ltd., in response to the demand for marine weather services in the rapidly expanding offshore business in south-east Asia. Forecasters in Singapore access data on ISDN links from Bracknell, and high-resolution satellite data directly from the Singapore Met. Service, over a leased line installed specially for the purpose.

Utilities

Business from the electricity, gas and alternative energy markets, has expanded during the past year, while coal continues to decline. Growth in the gas industry has been heavily influenced by the diminishing control of the market by British Gas. There has been a modest growth in services to electricity companies, as they continue to realise the benefits of weather services to predicting energy demand. Take-up of MIST by electricity companies has been encouraging, with sales of multiple systems to the National Grid Company, Seeboard and Nuclear Electric. The growing number of companies who use combined gas and turbine generators are also now taking weather services.

Following evaluation by the NRA Thames and North West regions, three additional NRA regions will start receiving FRONTIERS 'nowcasts' (forecasts up to six hours ahead) on dedicated lines in April 1994. Six of the seven River Purification Boards in Scotland are now receiving dial-up weather radar images and other services using MIST.

Consultancy and Training

A new package of environmental services for industry, regulators and planning authorities, called 'EnviroMET' was launched during the year. This is an area in which the Met. Office has not been active till now. 'EnviroMET' includes a short-range pollution dispersion model ADMS, the tried and tested global pollution dispersion model NAME, a noise propagation prediction model, LARRI, and the MORECS soil moisture system. The launch culminated in two well attended and successful seminars for Industry and its Regulators held at the end of March 1994.

ADMS has been used in an environmental impact assessment of factory discharges; NAME predicts plume dispersals and deposition taking into account effects due to the weather, and LARRI has been used to assess several noise complaints.

In addition, the National Agromet. Unit, on a two-year contract to ADAS (the Agricultural Development and Advisory Service), supports agricultural advisers with problems related to environmental legislation, such as leaching of nitrates and pesticides into aquifers, odours from farms and noise from agricultural machinery.

Metstar has continued to expand its consultancy business in nowcasting, remote sensing and hydrometeorology. Major contracts won during the year include a study with the University of Salford on reservoir safety, collaboration on a C-band Polarisation and Doppler Radar Experiment (PADRE) in Italy and Germany, and development of a thunderstorm warning system for the National Rivers Authority.

Revenue from training courses held at the Met. Office College, Shinfield Park has continued to grow. Specialist courses have been developed to serve the needs of Aviation, Media, Education, Offshore and Marine and Agriculture sectors.

Commercial Instrumentation

CAMOS, the Met. Office's automated observing system, is now being marketed in collaboration with Aeronautical and General Instrument Ltd. (AGI). At the leading edge of local network and distributed processing technology, CAMOS was successfully launched at the 'Meteorex' trade show in Geneva. With CAMOS, meteorological data are processed, displayed and presented as coded messages, in the format required by the customer, for onward transmission over the meteorological or telecommunication networks. The system can incorporate sensors such as runway visual range systems.

Data Supply

We are continuing to develop our policy for releasing basic data and products to the private sector. During the year, we published our policy on releasing data for research purposes in the UK and developed a draft policy for wholesaling data and products. This is expected to be introduced during 1994, giving the private sector equivalent access to information to that of the commercial arm of the Met. Office, and providing a 'level playing field' for our private sector competitors.

We secured a contract with Eurotunnel against international competition. Hourly wind forecasts are now provided, 365 days a year.

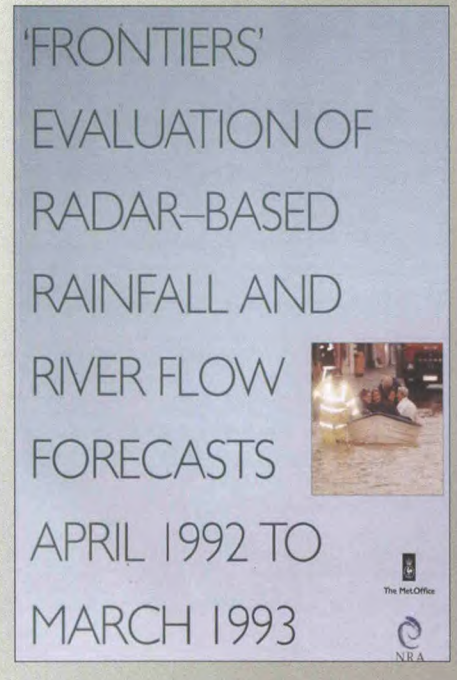
EnviroMET products are now being used by companies tackling environmental problems in planning and day-to-day management.

MORECS has become an established management tool in estimating leachate from landfill sites.

New temperature sensors are being installed on the Forth Bridge, and operators of the Tay Bridge also took services from the Met. Office this year.

Wind farms provide the main renewable source of electrical energy in the UK. In winter, many potential wind farmers and energy consultants took large quantities of wind data. Sales of services to the water industry have also held up well.

MetRoute, the routeing service for shipping, served vessels of all sizes ranging from QE2 at one extreme and Mike Golding making his solo circumnavigation aboard the yacht Group 4 Securitas at the other.



The joint Met. Office/National Rivers Authority report 'FRONTIERS Evaluation of Radar-Based Rainfall and River Flow Forecasts' was published and distributed.

Forecasting Operations

Observations

Forecasting the weather for short periods ahead depends not only on knowing the existing conditions over this country, but also over continental Europe and our surrounding seas. To predict changes 12–18 hours ahead needs observations from all of western and northern Europe, the North Sea and the east Atlantic. Predicting changes several days ahead needs observations of the initial conditions over most of the globe. Therefore, weather forecasting for the UK depends on extracting data from, as well as input of data into, the World Weather Watch (WWW), an international network of observations coordinated by the World Meteorological Organization (WMO).

The Met. Office makes significant contributions to this WWW programme every year. Over the oceans, our voluntary observing fleet of 520 ships and 34 oil rigs provides reports of surface weather, out of a global total of 7350. The fleet size has remained almost constant during this last year. Up to fifteen drifting buoys are deployed each year in data-sparse areas away from shipping lanes and one was contributed to the Arctic buoy programme this year.

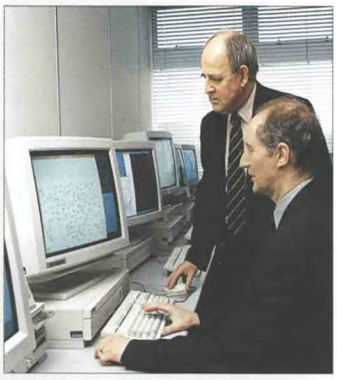
Also, the last three of the eight ASDAR systems (which automatically relay wind and temperature data from long-haul commercial aircraft) were delivered and installed on British Airways Boeing 747-400s. However, our contribution to the upper-air sounding programme from merchant ships had to cease at the end of the year to save money.

The Met. Office's contribution to the WWW network was maintained at 30 surface sites — manned 24 hours a day by professional observers, 8 land stations taking upper-air measurements, the Ocean Weather Ship at 57° N, 20° W in the eastern Atlantic, and nine fixed ocean buoys. There have been no changes in this network since last year. Except for the buoys, they also undertake measurements for other programmes such as ozone, ultraviolet radiation and pollution and, in addition, provide services for our defence, CAA and commercial customers.

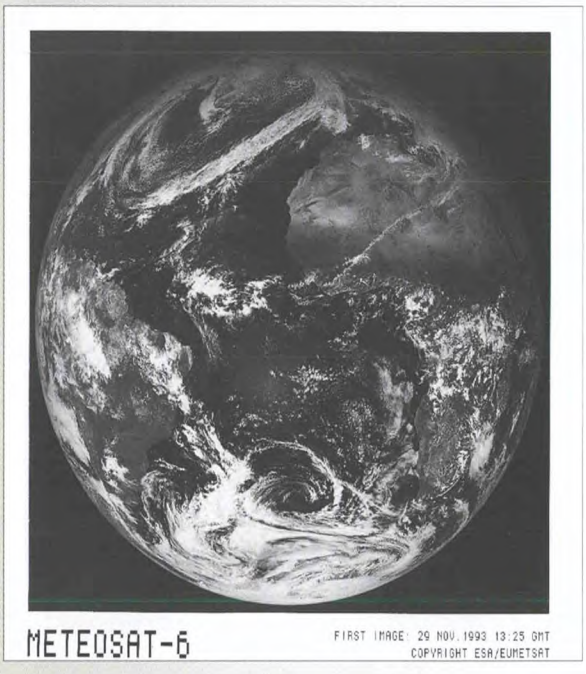
For regional forecasting within the UK, we maintain a secondary network of over 200 other stations (ten less than last year), many operated by auxiliary observers such as coastguards and power station personnel, who also provide data for activities such as low flying, airfield operations, and forecasting of local weather hazards. Measurement programmes are now totally or partially automated at 92 of the land stations.

As part of the improvement programme, two more Automated Weather Stations (AWSs) were deployed in harsh environments, on Great Dun Fell and Cairnwell, and another 13 Semi-Automatic Meteorological Observing Systems (SAMOS) were installed, allowing sites to be unmanned at times when visual measurements were not essential. Visibility sensors have been connected to some AWSs, and software written to process automated measurements of cloud base and amounts. An AWS was installed on the Sandettie Light Vessel, but the light vessels at St Gowan and Smith's Knoll were withdrawn from service. Future SAMOS and AWS programmes have now been reduced due to financial constraints.

Some instruments are provided for the US polar orbiting satellites; three flight models of the Advanced Microwave Sounding Unit for measuring atmospheric humidity have now been delivered by British Aerospace, and fully calibrated prior to transfer to NASA.



Dr. Peter Ryder (above), Deputy Chief Executive and Director of Operations with Mike Nicholls, Director of Observations (seated).



Some instability in two of the new Meteosat 6 observing channels is being investigated, but this, the first image from the satellite was received on 29/11/93 at 13:25 GMT.

A new rainfall radar at Clee Hill in Shropshire entered service in September 1993. This radar can measure wind fields within rain areas and the vertical extent of the rain cells.

Martin Stubbs (left) Head of Central Forecasting Office with Julian Hunt, Chief Executive.

The fixed ocean buoys extend to 15° W.

ERS-1 can survey the Earth through darkness and clouds for an entire 24 hours.

A total of 150,000 observations a day, 25 km apart in swathes 500 km wide, are now being received from the European Remote Sensing satellite, ERS-1.

Forecasters at headquarters and outstations can now display radar, satellite, upper air and surface data on their PC screens using the Outstation Display System (ODS), installed at 100 locations.

Operational Forecasting

Observations are the lifeblood of operational forecasting, but to have any value, 90% of them must be assimilated into computer models within three or four hours of the observation time. The massive effort of exchanging data and satellite imagery with the minimum of delay around the world, continues all day, and every day of the year.

But even with all the international co-operation, all the observations from ships and buoys, land-based stations, aircraft and balloons, there are still vast areas of the globe devoid of data. This lack of data means that errors will occur in analysing the initial state of the weather — errors which can grow very quickly and could become serious, if not checked by experienced forecasters.

Ensemble methods

One technique we are currently examining is the use of ensemble forecasting (see Research Section). Three times a week, the European Centre for Medium-range Weather Forecasts (ECMWF, based at Reading) supplies us with some 32 forecasts for ten days ahead. The forecasts diverge during the period. The amount of divergence is a measure of the atmosphere's predictability, and provides useful guidance for advising customers of medium range trends in the weather.

NWP models

Operational forecasts for five days ahead are produced by our Unified Model at Bracknell and distributed worldwide twice a day within five hours of the observations being received. Forecasters are supplied with three types of output from the Unified Model — global, limited area and mesoscale. Each uses different grid lengths and produces forecasts for different areas. Global model output is available twice a day and provides forecasts for six days ahead. Its wind forecasts are used by civil aviation. Output from the Limited Area Model is available four times a day, and provides more detail over the North Atlantic, Europe and much of the North American continent. Mesoscale output uses a very much closer grid than the others, and provides detailed information on temperature, cloud and fog for the UK and the North Sea area. It is run twice a day, based on midnight and 0600 data.

Interpretation

The job of the forecaster is to interpret these computer analyses taking into account other information such as satellite and radar imagery, and most of all, experience. For example, the depth of centres of tropical cyclones can be estimated by looking at their satellite images, and the numerical model now provides very good guidance on the forecast path of these storms for periods up to several days ahead. Under bilateral arrangements, we send these forecasts to several recipients, for example the US Air Force base at Guam and the Bureau of Meteorology in Melbourne, who in turn pass the information to the Pacific Islands.

Snow, Rainfall and Gales

Closer to home, the UK radar network provides a great deal more information about the intensity and occurrence of rainfall than can be obtained from surface observing stations. Using this, and taking into account the characteristics of the model, forecasters are able to issue better guidance on precipitation.

In fact, during 1993/94 there were 36 days when warnings of heavy rain, and 16 days when warnings of snow heavy enough to cause disruption were issued. In particular, on Wednesday 8 December, a deep and intense depression crossed the Southern Uplands of Scotland and resulted in severe gales over much of southern Britain later in the day. Early on Thursday, it caused much damage and at least ten deaths. The death toll could well have been higher and the disruption far greater but for warnings issued the day before.

Theory and practice

To provide feedback on how the models' outputs behave in different weather situations, forecasters compare them with the weather that actually occurred. Over the past year, the 24-hour pressure-pattern forecasts have, in the estimation of our forecasters, provided good guidance on 95% of the 726 model runs verified. The guidance for rainfall 24 hours ahead has been useful on 88% of computer runs (compared with 78% last year). The Chief Scientist ensures that support to Central Forecasting Office and other operational centres by our research scientists is maintained at a high level.

Finally, this year saw the publication of a new revised edition of the *Forecasters' Reference Book,* which sold out within weeks of its appearance, requiring an immediate reprint. *Images in Weather Forecasting,* a new manual on the interpretation of satellite imagery, was completed, ready for publication by Cambridge University Press in 1994.

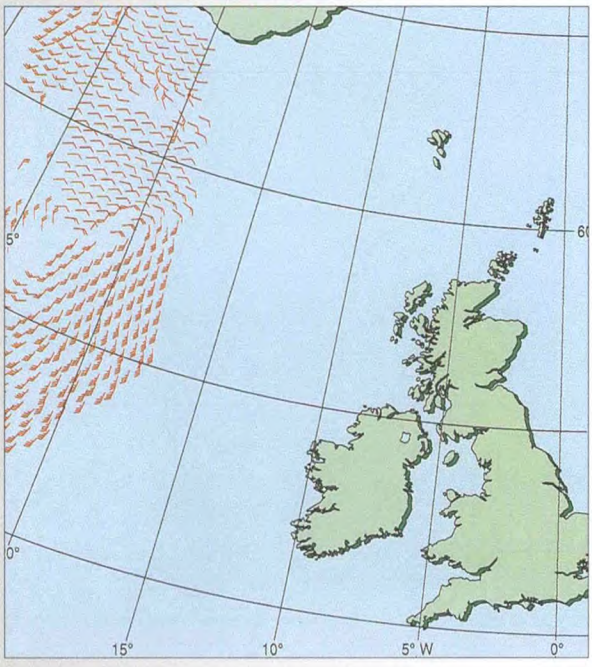
Information Systems

Rapid transmission and processing of information are essential to the business of weather forecasting. Timeliness is of the essence when dealing with products as perishable as weather forecasts for a day or two ahead. Last year saw completion of several measures, and initiation of others, aimed at improving services. These measures have included direct application of information technology to prompt delivery, organisational changes, and better presentation of products and services.

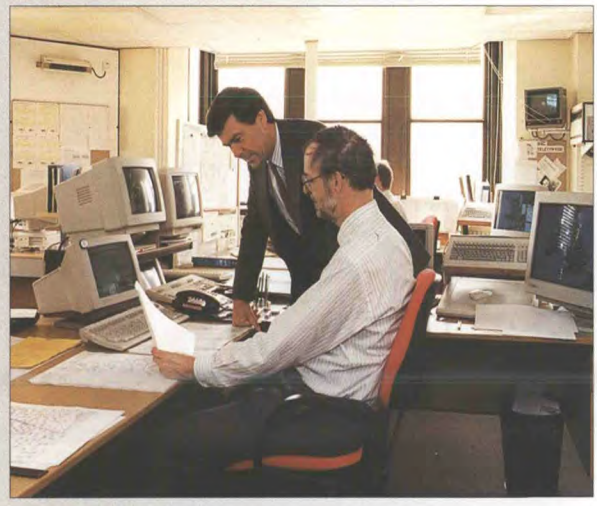
Over the last ten years technologies, techniques and working practices of computing and telecommunication have converged. During the first part of 1993 we developed plans to combine the operations areas of telecommunication and computing, with the objective of improving service quality with fewer staff. The first step was taken with the collocation of the two operations areas in February 1994. Various improvements to services will be phased in over the following six months, at the end of which efficiency measures will also take effect.

New computing platform

Numerical Weather Prediction (NWP) and the Climate Prediction Programme (CPP) are major users of large-scale scientific computing. For most of 1993, two separate Cray Y-MP8/864 computers were used, one for CPP, funded by the Department of the Environment, and the second for NWP and meteorological research. The CPP called for a fourfold increase in computing resources in 1994 and a modest increase in throughput, around 50%, was also needed to maximise the benefits obtainable for NWP from the Unified Model. It quickly became apparent that significant savings in capital and support costs could be achieved by using a single platform to meet both requirements.



A project to derive sea surface winds from measurements of wave height from ERS-1 was successfully completed; these are particularly valuable from oceanic areas in the tropics and southern hemisphere for input to the numerical models.



During the year, the first phase of OPUS was installed at two Weather Centres.

Dr Roger Wiley, Director of Information Systems.

The combined operations centre is now known as the IT Operations Centre.

A new Cray Y-MP C90/16256 system was delivered and installed in March.

Weather Information Network

The Weather Information Network (WIN) will rationalise the Office's internal telecommunication network and offer more flexible methods of delivering services to our military and commercial customers. After some years of investigations, formal procurement began in December. A capacity study is also under way to determine the optimum arrangements for co-operation within MOD in the use of telecommunication bearers. WIN will be based on X400 message handling protocols and incorporate up-to-date network management tools.

Workstations

Workstations have now been introduced into several areas of the Office. The Hadley Centre for Climate Prediction and Research and the Forecasting Research Division are now benefiting from the much better visualisation facilities that are now available. The HORACE project is deploying workstations at HQ RAF Strike Command and in the Central Forecast Office at Bracknell. The first phase of HORACE is now running under test in parallel with older systems at Strike Command and some impressive demonstrations have been shown on the system in the Central Forecast Office. Further workstations will be deployed where removal of work from the mainframe computer system allows savings to be made through 'right-sizing'.

Resilience

As the Office relies more heavily on automated systems, reliability and resilience become correspondingly more important. Most of the critical single-points-of-failure in the central infrastructure are covered by reserve systems or contingency plans. However, a very clear single-point-of-failure was identified where the key message switching systems and telecommunications links are concentrated in the main building at Bracknell. British Telecom used to re-route lines in an emergency, but this option is no longer possible with digital connections. The problem has been resolved by setting up a triangle of packet switches, linked by megastream bearers, which interconnect the Met. Office's College at Shinfield Park with Bracknell and HQ RAF Strike Command. There is now a very high degree of resilience for critical telecommunications, both internationally and nationally, and enhanced ability to bypass failures in the outfield.

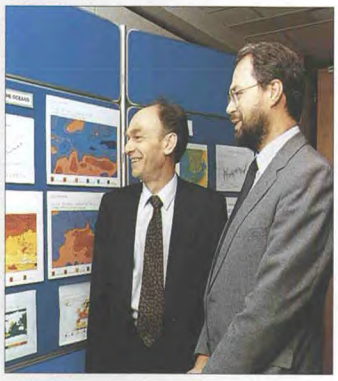
The volume of observational data and range of products and services has continued to grow. Inevitably, this has led to more demands for communications. By 1992, the main message switch at Bracknell was approaching the limit of its capacity and enhancement was essential. Its upgrade came fully into service early in the current year. The previous message switch had been known, somewhat obscurely, as Phase IV; a competition was run to find a new name. The winner was TROPICS — Transmission and Reception of Observational and Product Information by Computer-based Switching.

Weather Centre IT facilities

IT facilities at Weather Centres have become fragmented as technology has advanced and a variety of systems, each most appropriate to customers' demands, has been installed. Outstation Production Unified System (OPUS) is a project to link these systems with a local area network (in anticipation of WIN) to improve responsiveness to customers. Later phases of OPUS will integrate the Outstation Display Systems (ODS) into OPUS, and OPUS itself will be served through WIN.

Financial and management systems

The Finance and Accounting Management Information System (FAMIS) has settled into routine use during the year. The Finance and Contract Management Sub-system, which was developed in-house following the failure of an external contractor, came into service later in the year. It will take time to ensure that all the data are consistent.



Developments in Research

Forecast models

The Met. Office's weather forecasts and climate simulations are based on the unified atmosphere–ocean model. This was introduced for operational forecasts in 1991, but our systematic development plan has led to many improvements since then.

Climate simulations place specially severe demands on the model, and satisfying these has led to better treatment of physical processes, with benefits also for weather forecasting. More complete representation of turbulent mixing in unstable boundary layers has been included; drag due to unresolved gravity waves has been made more accurate, leading to a 5% reduction in forecast errors. Forecasts of convection have been greatly improved by including the effects of cold air downdraughts.

A major new development during the year has been a prototype version of an ocean forecasting system for the Royal Navy. This forecasts temperature, salinity and currents in the Atlantic Ocean north of 30° S, using a 110 km horizontal grid and 20 levels throughout the ocean depth. Initial tests of the model included the assimilation of 3,000 observations over a period of a month to provide an analysis of the three-dimensional ocean structure.

A high-resolution version of the forecast model, the mesoscale model introduced at the end of 1992, produces precipitation forecasts that add value on a substantial number of occasions to those of the larger regional model. A new version has been tested which is run through a continuous cycle, rather than being restarted by interpolation from a coarser model for each run. Forecasts of fog and cloud in these tests were very promising, with success rates over 60%.

Ensemble forecasting

A promising method of producing statistical forecast information, especially for periods of a week or more into the future, is to use a large number of separate runs of one or more models, each using a slightly different starting analysis, so as to generate a set of forecasts from which probabilities of different types of weather can be deduced. Such a system is used as an input to the extended-range forecast advice supplied to external customers, but in the future, may allow this advice to be generated automatically.

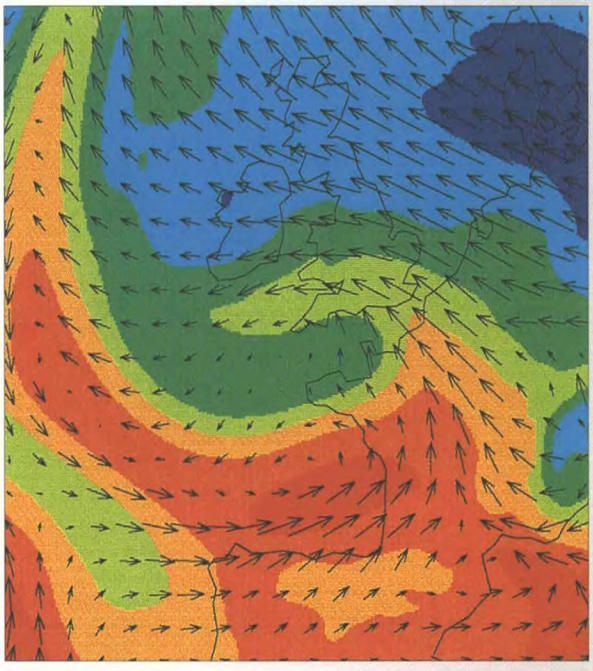
A joint project is being conducted with the ECMWF to assess the value of this approach in medium-range forecasting, and to determine how best to present the results to forecasters and customers.

Rainfall

Further progress has been made on the automated replacement, known as Nimrod, for the FRONTIERS very-short-range rainfall forecasting system. Automated methods of extending rainfall analyses outside the range of the radar network using satellite data have been successfully developed, and those for identifying radar echoes caused by phenomena other than precipitation, work as well as the present techniques of human intervention. The whole system is on course for operational implementation in 1995.

The C-130 has completed a $1m, four-year research programme on clouds and climate change, sponsored by the International Petroleum Industry Environmental Conservation Association (IPIECA).

Dr Paul Mason (left), Chief Scientist and Director of Research with Dr David Carson (right), Director of Climate Research.



The forecast for 15th February 1994, showing a plunge of cold air just south of the tip of Cornwall. It was responsible for the heavy snow in southern England, beginning in the west country and spreading north-eastwards.

In winter, the main cause for concern is nitrogen dioxide formed from reactions with car exhausts, while in summer, ozone produced by sunlight-driven chemical reactions is the principal hazard.

Applied research and atmospheric processes

Cirrus clouds

The representation of cirrus clouds in forecasting and climate models is at present rather too simplified, and observational studies are being undertaken with a view to improving this. The Meteorological Research Flight C-130 aircraft carried out detailed investigations of microphysical and radiative properties of cirrus clouds, jointly with two other research aircraft from Germany, during September and October 1993. The project was partly funded by the European Commission.

Stratocumulus clouds

Low-level stratocumulus cloud is also poorly represented in models, a factor which can cause poor forecasts and major systematic errors in climate simulations. Research with a very-high-resolution numerical model has elucidated the conditions governing stratocumulus break-up. Data obtained by the C-130 aircraft have demonstrated that penetration of stratocumulus by cumulus clouds can generate appreciable amounts of drizzle, even though neither cloud type would be capable of producing rainfall on its own. Both these results have the potential for improving forecasts in the future.

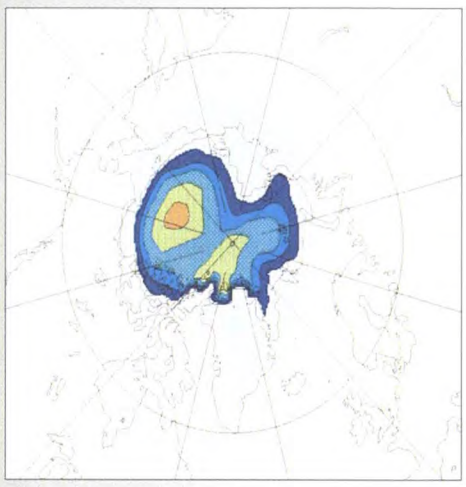
UV radiation

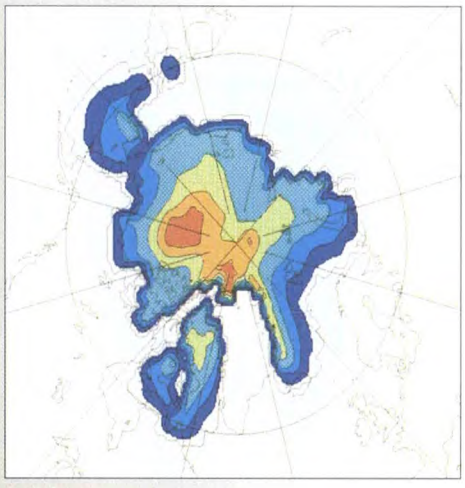
Concern from the public and government about the environment has led to a number of developments in environmental forecasting. A scheme to forecast the intensity of ultraviolet radiation at the ground (a contributory factor in the development of skin cancer) has been introduced. It depends on solar elevation and the total amount of ozone in the atmosphere above, and will alert the public to the dangers of getting sunburnt within a specified exposure time. The service went public in March 1994.

Pollution

Pollution levels within major cities in the country can now be predicted using a simplified 'box' model. Both nitrogen dioxide and ozone have been linked to apparent increases in asthma in children and other respiratory complaints. Accurate predictions of pollution events are likely to be influential in persuading people to use public transport instead of driving their own cars into city centres. The NAME model, developed for predicting dispersion and deposition of radionuclides (fallout) following a nuclear accident, is being extended to operate at higher spatial resolution than before, and the operational weather forecasting model is being adapted to include a large number of trace gases and the chemical reactions between them. Both developments have potential applications in regional pollution forecasting.

The Office is involved in considerable collaboration within Europe, through the COST programme, sponsored by the European commission, and through a programme to intercompare and harmonise the large number of short-range dispersion models now available.





Climate Research

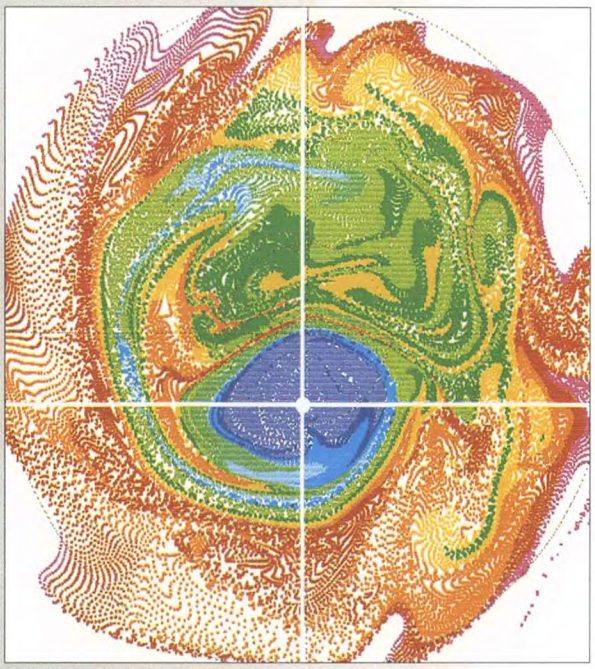
Climate change continues to be a topic of major worldwide concern. Work on its monitoring and prediction is the main focus of the Hadley Centre. The Centre also hosts the Technical Support Unit for Working Group I of the Intergovernmental Panel on Climate Change, charged by WMO and UNEP with completing a new Scientific Assessment during 1995.

Climate change prediction

Climate prediction requires models which can simulate today's climate and the processes important for climate variability and change. An essential tool is the Hadley Centre's 'coupled' model, which combines models of the atmosphere, oceans, land and sea-ice. This is continually being refined. For example, addition of the dependence of convective entrainment on depth of convection (based on comparisons with the Met. Office's 1 km resolution convective cloud model) has improved simulation of Asian monsoon circulation, and a multi-layer soil hydrology model has improved simulation of rainfall over land. Simulation of the distribution of sea-ice has also been improved by modelling its drift with ocean currents.

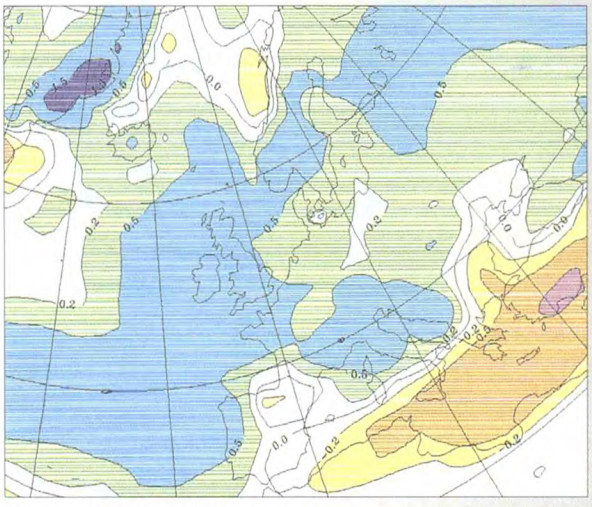
Development has also continued on a version of the coupled model with a high-resolution ocean and on methods of ocean model spin-up. Work is well advanced, in collaboration with universities and NERC and other institutes, to include interactive vegetation processes and ocean biology.

A long run of the coupled model is under way as part of a second 'transient' experiment to study the response of climate to the evolving changes in atmospheric composition. Over a 100-year control run, the variability on interannual to decadal time-scales approximates to the observed value. Using the atmospheric model coupled to a shallow ocean, its sensitivity to doubling the carbon dioxide has been estimated to be 4 K, compared with 3.4 K for the previous model. This study has been used to drive a nested 50 km-mesh model of the European area to provide more details of simulated climate changes. Preliminary assessments have been made of the indirect and direct effects of sulphate aerosol on the global climate response. These appear likely to offset part of the effects of increased greenhouse gases, and bring the spatial and temporal features of the response into better agreement with the twentieth century temperature record.

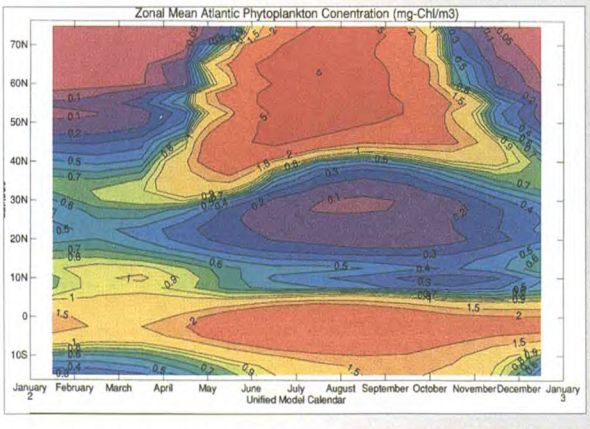


Observations of the transport of long-lived tracers throughout he atmosphere, together with data from UARS mission, helps in the analysis of the dynamics of the stratosphere. The diagram shows the way in which warm air from the lower latitudes mixes with cooler air at the Pole.

Output from the Hadley Centre's coupled model, showing the difference in extent and depth of sea ice between Summer (top) and Winter (bottom).



With a doubling of CO_2 in the atmosphere, the global model indicates that the mean winter rainfall (averaged over ten years) would increase little more than half a millimetre per day (blue) over the British Isles, northern France and around northern Italy, and remain roughly the same (white) or become slightly drier (yellow/brown) over most of Spain and North Africa.



'Zonal Mean Atlantic Phytoplankton Concentration (mg–Chl/m^3)'

The effects of the 'blooming' of phytoplankton in the oceans are also being studied. The diagram shows how the concentrations increase at various latitudes throughout the seasons (along the bottom axis).

Climate monitoring

Analyses of observed data are essential, in order to test models and to study and monitor climate variability and trends. Work on these has continued, in collaboration with the University of East Anglia's Climatic Research Unit and others, particularly for surface and near-surface temperatures and global patterns of surface pressure. Of special interest are analyses of daily maximum and minimum temperature, which now cover 40% of the land surface; over most of this area minimum temperatures have risen more than maxima over recent decades. The latest model runs with increased carbon dioxide also show a reduced diurnal range.

The surface temperature record has confirmed expectations that the eruption of Mount Pinatubo in 1991 would cool global mean temperature. As a result, 1993 was cooler than the very warm years of 1990 and 1991, but still in the top ten of the whole 138-year record.

Climate variability and seasonal prediction

The causes of interdecadal climate variability are being examined in experiments using the Unified Model and the Hadley Centre's globally complete analyses of sea surface temperature and sea-ice extent. An ensemble of four experiments for 1949–90 has demonstrated the strong influence of surface temperature variations on decadal rainfall variability in the tropics. The potential of this for seasonal prediction is illustrated by the significant skill of experimental seasonal forecasts for West Africa and, especially, north-eastern Brazil. This success was continued in 1993, with a correct prediction of mostly dry conditions in both regions. Intermittent warming of the Pacific associated with the El Niño – Southern Oscillation (ENSO) phenomenon has an important role in seasonal prediction. Hindcasts of ENSO events are being undertaken with both fully coupled and simplified models. Techniques of ocean data assimilation are being introduced to initialise the Pacific ocean circulation model used in these studies.

Middle atmosphere

Results from the Upper Air Research Satellite (UARS) are providing new insights into the dynamics and chemistry of the stratosphere. Analyses using a special version of the Unified Model are provided daily to the UARS science team, via NASA. For probably the first time, the analysed tropical wind fields show semi-annual oscillations, previously evident from rocket soundings.

Major weather events of 1993/94

Temperatures reached nearly 30 °C in the UK in June and manufacturers needed extra staff to deal with the demand for ice-cream.

The 10th and 11th of June brought exceptional thundery rain with flash flooding in south-west England and North Wales (Llandudno).

Storm damage to Genoa in September was put at a trillion lire.

Umbria and Tuscany saw their rivers flood in October.

Typhoon Ira passed close to Hong Kong on 4th November forcing a Boeing 747 off the end of Kai Tak's runway, fortunately without loss of life.

Every year the weather is a constant source of news. Some of its most violent effects reach our TV screens and newspapers, many go unreported. Economic and political events often oust weather-related items from news bulletins which would otherwise have been reported.

Britain's temperate climate produces nothing to compare with natural disasters which strike other nations; major weather events in this country are newsworthy because of their rarity rather than their scale. This short and highly selective review is a reminder of some of the events which made it to the front page in 1993, and some that did not. They serve to give a perspective on the power of the atmospheric processes which shape our planet and our lives.

April brought news that the Chinese province of Quinghai had been largely buried in snow since January, and Mongolia had experienced the worst snowstorms for 30 years. A two-hour long 'cataclysmic' sandstorm hit the Chinese province of Gansu in May, while in the UK, a tornado transferred a flock of twenty-six Welsh sheep across five stone walls and a river.

June in the USA brought violent thunderstorms over the Mississippi valley. A sewer failed under an Atlanta car park leaving a huge crater; one of the cars was found miles away in a storm drain. The flood crest around the city of St Louis reached 49 ft, only 3 ft below the levees, just averting disaster. It was September before the Mississippi returned to near normal levels. Meanwhile, the UK had a heatwave and expansion joints on some sections of motorway could not cope.

By July the heavy monsoon rains in the north-east of the Indian subcontinent were causing huge landslides and floods and almost half of Bangladesh was under water. Periodic catastrophic downpours continued into August; heavy rain fell on Chittagong for two days disrupting all forms of transport and leaving the airport knee-deep in water.

Europe's turn came in September when severe thunderstorms affected southern Europe from Marseilles to Udine; some parts of the southern Alps had half their annual rainfall in a few days and the Rhône Valley town of Brig was declared a disaster area. Storms continued into October, paralysing Rome early in the month.

By mid-July the Mississippi and Missouri were at record levels, bursting their banks, and uncrossable over 200-mile stretches.

Uttar Pradesh, hitherto a drought zone, suffered many fatalities as the rains finally struck in July.

Dhaka was flooded early in September after three days of heavy rain.

In the UK the greatest problems were around Chichester which was almost cutoff by floods for several days during December.

In January a long series of storms started moving up the east coast of America dumping large amounts of snow over the eastern states and pumping Arctic air far to the south.

The outbreak of cold air on 28th March triggered more than 20 tornadoes in the USA; among the casualties were many in a church that collapsed during a service.

Venice was flooded twice; Lake Maggiore almost reached its 1907 record level and flooded Locarno.

Arctic easterlies reached the UK mid-November and on the 20th London had its first November day with lying snow for 24 years. The 22nd was one of the coldest November days on record over much of the UK. Continuing its determination to break all records, as last year, Erzurum in Turkey saw its temperature fall to –28 °C breaking the previous November low by nearly five degrees.

December was wet and windy over Europe. The 8th brought a deep low across the British Isles preceded by severe weather warnings. Many places had gusts to 60 kn, the highest was 84 kn at Pembrey Sands. Over North Wales heavy rain caused the worst floods for 40 years in the Conwy valley. By Christmas the Rhine, Moselle, Sambre, Meuse and Seine were over their banks to give the worst floods for 60 years (in Trier they say the worst for 199 years).

Christmas Day was bitter in the UK but the snow flurries caused little excitement, they had been forecast far in advance. In the Alps the snowfalls were the deepest for 20 years.

January brought the USA back into the news. Temperatures fell as low as –40°C in Minnesota. On 11th February snow and freezing rain virtually shut down the capital and New York. Six centimetres of ice brought down trees and powerlines in Kentucky, and caused severe traffic problems. Flooding is rarely reported in Africa, but in early January heavy rain fell in south-east Tanzania destroying 1000 homes and killing many in flash floods.

A depression deepened explosively in the south-west approaches to the UK during the 2nd of February. As the fronts swept north they brought heavy rainfall and flooding in many parts of the south and west, and dangerous snow conditions in the mountains.

At sea the force 11 storm stopped Irish Sea ferries and a Greek ship, the *Christinaki,* lost a hatch cover 250 miles south-west of Land's End and rapidly sank with all hands.

Erzurum continued its attempts on the low temperature record, twice breaking its lowest recorded February night minimum, creating a new one of –30 °C, set on the 3rd.

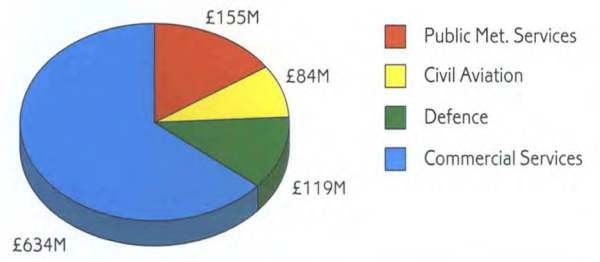
Focus on Facts

The economic benefits of weather information

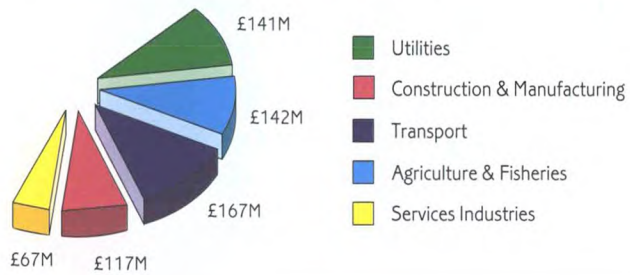
A recent survey, carried out by independent consultants endeavoured to estimate the economic and social benefits of the Meteorological services to the UK economy and to users of specialised services, including public meteorological services, defence, aviation, research and commercial services.

Their survey suggested that the total economic benefit of Meteorological services could reach £1 billion per annum. This conclusion is being assessed by the Met. Office and Met. committee. This monetary value did not include unquantifiable benefits categorised as Social Benefits, such as reductions in casualties in fatal and non-fatal accidents, information which enhances the quality of life and increased effectiveness during periods of crisis or war.

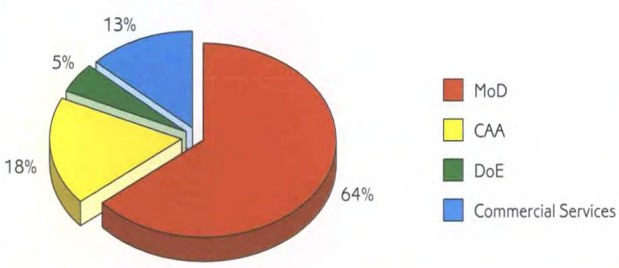
Overall Economic Benefits



Economic Benefits of Commercial Services

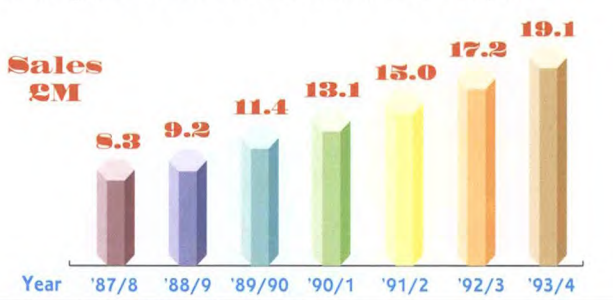


Met. Office income sources

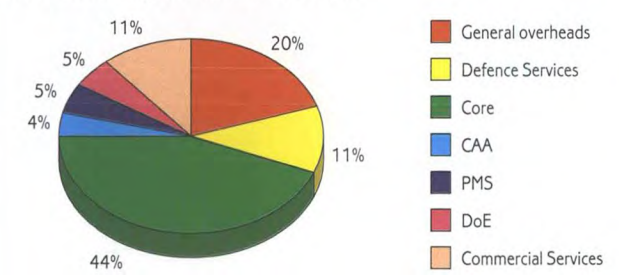


Commercial Revenue

a further growth in our revenues of 24% is forecast over the next five years.



Met. Office expenditure breakdown



At the end of the year the Office employed the equivalent of 2470 full time staff — a decrease of 56 during the year. Staff losses by resignation, although slightly higher than in the previous year, remained at a low level. The total number of staff recruited was 117. Of these 66 were graduates destined for scientific posts.

Martyn Bittleston (left) Director of Finance & Administration outside the Met. Office College with Dr. Bob Riddaway, Principal of the College.

The Met. Office College

The Met. Office College's standards of excellence are internationally recognised. Over 300 students from more than 60 countries have taken part in our professional training courses, many through the Voluntary Co-operation Programme.

Courses cover almost every subject associated with meteorology and follow guidelines laid down by the World Meteorological Organization (WMO). Courses are modular, and suitable for people at all stages of their careers, from new recruits to experienced meteorologists. We can arrange on-the-job training, enabling students to work alongside experienced staff in Met. Office departments, for example in forecasting, observing and engineering.

The Met. Office College keeps up-to-date with the most modern training methods. It is fully equipped with closed circuit television and video and the 86-seat cinema has film and video projection facilities. Computing facilities include word processors, self-teaching systems on personal computers, and systems linked to the mainframe computing centre at Bracknell.

TV and sound studios are available for training in broadcasting, and there are specialised classrooms for computer programming instruction, an audio-visual resource room, and an extensive library.

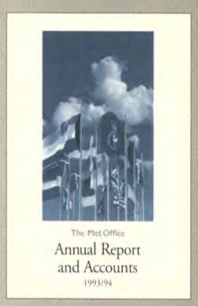
Many National Meteorological Services are now under pressure to reduce running costs by selling their services to industry and commerce. The Met. Office has had many years' successful experience in sales and marketing, and can pass this on to other National Meteorological Services (NMSs) through our new Commercial Skills courses.

Our courses equip delegates with the most up-to-date expertise, for example in TV presenter training.

Met. Office Annual Report Publications

The Met. Office publishes its annual reports in three booklets, the Annual Review, Annual Report and Accounts and the Scientific and Technical Review.

The Annual Review summarises the Met. Office's activities during the year. Its broad view of the Met. Office is of particular interest to those who do not specialise in meteorological science, but who are interested in the uses of weather intelligence. It is available free of charge, while stocks last, by contacting the Enquiries Office at Bracknell.



Full details of the Met. Office's accounts are contained in the Annual Report and Accounts, as required by the Treasury. Copies of the Annual Report and Accounts are available from HMSO bookshops in London, Bristol, Birmingham, Manchester, Belfast and Edinburgh, and from HMSO's accredited agents listed in Yellow Pages.

The Scientific and Technical Review gives a more detailed account of the research work being carried out at the Met. Office. This year the emphasis is on developments in Central Forecasting, Commercial Services and Atmospheric Processes Research Divisions. There is also a bibliography of papers published by scientists at the Met. Office over the last year. Copies are available, while stocks last, from the Enquiries Office at Bracknell.

To find out more about our services, you can contact your nearest weather centre or the Enquiries Office at Bracknell. The new number, operational from 1st August 1994, is shown in brackets.

Weather Centres

Aberdeen	0224 210574	(01224 210574)
Belfast	08494 22339	(01849 422339)
Birmingham	021-717 0570	(0121 717 0570)
Bristol	0272 279298	(0117 9279298)
Cardiff	0222 397020	(01222 397020)
Glasgow	041-248 3451	(0141 248 3451)
Leeds	0532 451990	(0113 2451990)
London	071-831 5968	(0171 831 5968)
Manchester	061-477 1060	(0161 477 1060)
Newcastle	091-232 6453	(0191 232 6453)
Norwich	0603 660779	(01603 660779)
Nottingham	0602 384092	(0115 9384092)
Plymouth	0752 251860	(01752 251860)
Southampton	0703 228844	(01703 228844)

Most Weather Centres are open 24 hours a day, 7 days a week. A few are closed overnight but an answering service is provided.

Past weather and climate information can be obtained from our Bracknell Headquarters or

Belfast Climate Office 0232 328457 (01232 328457)
Edinburgh Climate Office 031-244 8362 (0131 244 8362)

These offices are open during normal working hours.

International Marine and Offshore services enquiries: +44 (0)224 211840 (+44 (0)1224 211840)
International Commercial Enquiries: +44 (0)344 856283 (+44 (0)1344 856283)
Recruitment 0344 856038 (01344 856038)

Information on our Library and Archive, including the loan of weather books, videos, slides etc., can be obtained from The National Meteorological Library at Met. Office headquarters:

Enquiries Office 0344 854455 (01344 854455)

The Met. Office, London Road, Bracknell, Berkshire RG12 2SZ,
Telephone: 0344 854843 (01344 854843).

Data Protection Act

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The Met.Office

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