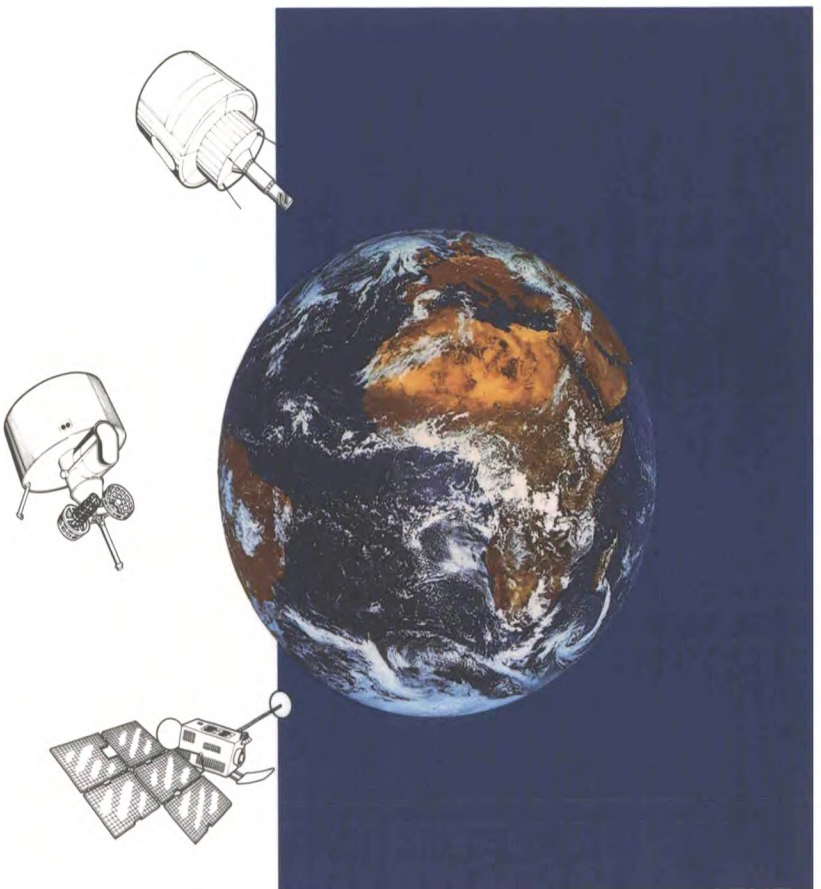
The Met. Office

Annual Review 1990/91



Annual Review 1990/91

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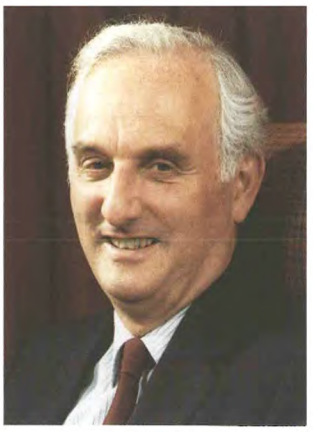
Foreword



The move to Executive Agency status in April 1990 has been one of the most important events in the recent history of the Meteorological Office. It has provided a stimulus for reorganizing our commercial activities, streamlining our operations, and placing greater emphasis on the quality of our services.

At the end of such a demanding year, it is gratifying to be able to report that we exceeded our commercial revenue targets and achieved the planned reduction in net operating costs, and produced measurable improvements in the accuracy of our forecasting services. The success of our commercial services is all the more encouraging when considered against the background of the depressed business climate during the past year.

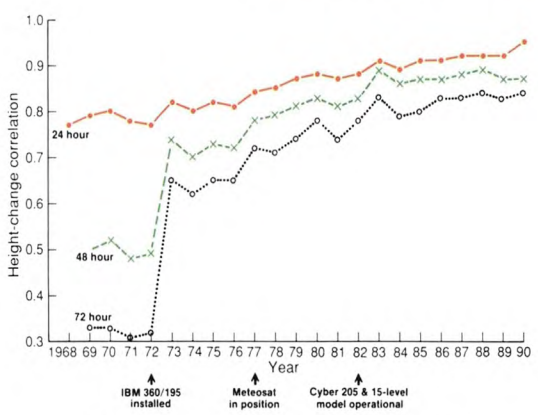
Severe weather, in the form of winds and snow, were well forecast through 1990/91 on all occasions, and false alarms were not raised. Forecasts out to 30 days have completed extensive customer trials successfully and many other new services were introduced in response to customer demand.

These results have been achieved by exploiting information technology wherever possible, through continued refinement and improvement of our forecasting models and observational data, and through the hard work, skill and commitment of our staff.

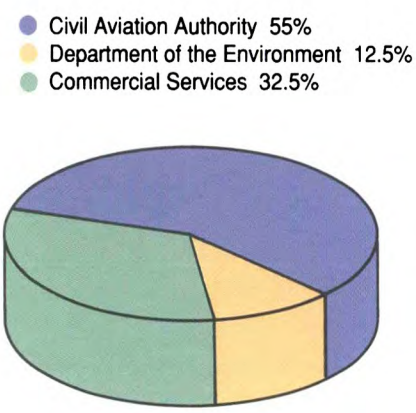
However, we still have to make allowances for the unpredictable. During this year the Gulf war has made particular demands on our resources. Staff were redeployed to the Gulf and within the United Kingdom to provide comprehensive services for the armed forces. New high-resolution models for the region proved invaluable in predicting the highly variable weather conditions

which occurred there. The continuing effects of the smoke plume from the oil fires in that region are of great concern; the Meteorological Research Flight aircraft has provided extensive detailed information on its dispersion and composition.

Substantial investment in research continues to be one of our highest priorities. This year saw the opening by Mrs Thatcher of the Hadley Centre for Climate Research. This Centre is addressing the enormously challenging task of forecasting climatic change well into the next century. The Centre includes a Climate Prediction Unit, supported by the Department of the Environment, which is equipped with the Office's second Cray computer.



HOW THE FORECASTS HAVE IMPROVED
For north-west Europe and the eastern North Atlantic from the coarse-mesh forecasts.



INCOME 1990–91

Through my chairmanship of the Scientific Assessment Working Group of the Intergovernmental Panel on Climate Change (IPCC), whose report was published in August 1990, the Office has played a large part in the international assessment of the climatic effects of the increase in greenhouse gases which are resulting from human activities.

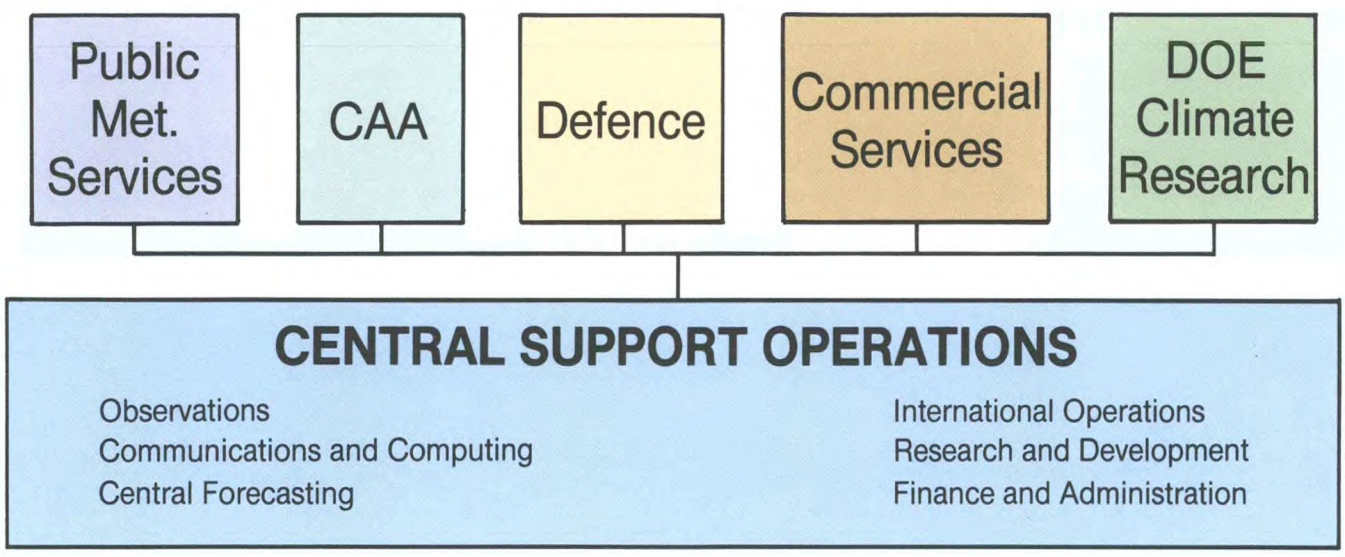
By its very nature, meteorology is a very international activity. The Meteorological Office is increasingly involved in co-operation with other countries (particularly those in the European community) in the exchange of data and information, in research and in the development of meteorological services to aviation and to other commercial customers. Our objective is that the whole community should benefit from this closer co-operation.

Sir John Houghton

Operations and organization

The Met. Office recognizes the increasing customer demand for even greater accuracy and range of meteorological services, greater public awareness of environmental issues, and the rapid developments in the relevant science and technology.

The Met. Office provides services to five major customer categories: the general public, civil aviation, Defence, industry and commerce, and the Department of Environment for the climate research programme.



All customer services depend on the central support operations of observing, communications, computing, forecasting, international exchange of data and organization of meteorology, research and development, and training of staff — these comprise the bedrock on which our operation is founded.

Our customer care practice and long history of experience in weather forecasting — the service started in 1855 — enable the Met. Office to provide the highest quality, range and reliability of data and services.

During the past year, particular attention was focused on development and achievement of quality, accuracy and client satisfaction targets. Our continuous investment in research and development enable our weather forecasts for three days ahead to be now as accurate as those issued twenty-five years ago for the next day. All our techniques are geared to meeting the diverse needs of customers — be they long-range predictions or forecasts just an hour ahead.

Peter Ryder

Keith Browning

Bernard Herdan

Michael Bowack

With the advent of Agency status on 2 April 1990 the Office was reorganized into four Directorates, two of the four Directors joining the Office from the private sector. The Directors are:

Peter Ryder: *Director of Operations.* Responsible for the provision of observations, instrumentation, communications, system developments, technical support, data processing, computer systems and operations of central and Defence forecasting offices, supply of public meteorological services and services to the Civil Aviation Authority, international support services, the National Meteorological Library and National Meteorological Archive.

Keith Browning: *Director of Research.* Responsible for implementing the Office's research programme and for the DOE-funded research activities.

Bernard Herdan: *Director of Commercial Services.* Responsible for the marketing, sales and provision of services to industry, and commerce.

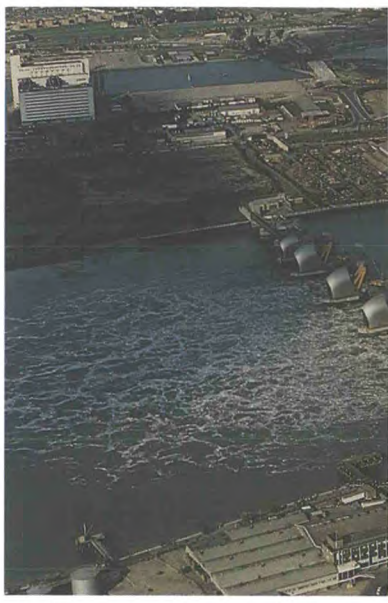
Michael Bowack: *Director of Finance and Administration.* Responsible for finance, planning, personnel, training and administration services.

The four Directorates are arranged into nine Divisions which meet the special needs of service provision to the five major customer groupings and the supporting central functions. There are some 2500 personnel in the Office — nearly half of whom are employed at or close to the Headquarters in Bracknell; the remainder serve at around 100 locations in the United Kingdom, Germany, the Mediterranean and the South Atlantic. Many of our staff are located at, or close to, the customer's operations — be they at television studios, oil rigs, airfields or regional Weather Centres.

Recruits come mainly direct from school or university. Most attend our Training College early in their careers and return later, or go to external institutions, for further training depending on their specialism. Some are able to remain working in their chosen area of interest and become promoted to senior positions. Others develop their career by applying their experience and knowledge in a different discipline in the Office.

Public Met. Services

Although many of the services provided by the Met. Office are carried out on a commercial basis, some are funded by Government and provided on behalf of the public in the national interest. These Public Meteorological Services are mainly concerned with the crucial task of providing warnings and advice in emergency situations.



Nineteen-ninety saw some of the biggest tidal surges in the last 30 years. The Thames barrier was raised six times compared with only four operational closures in the previous 8 years.

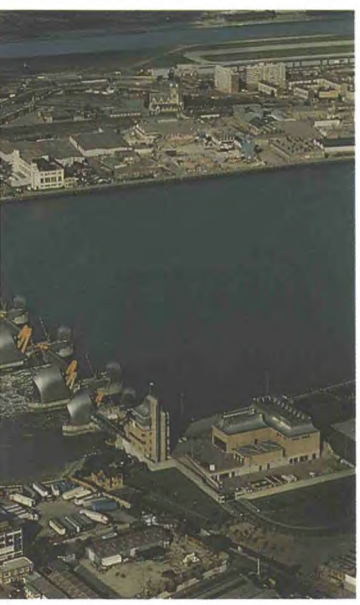
The National Severe Weather Warning Service

This year a comprehensive warning system was brought into service to ensure that emergency authorities and the public receive as much notice as possible on occasions of severe weather. When there is a serious risk of severe weather, warnings are distributed — in some cases three or four days in advance. Once such a warning is issued, it is updated at least daily. These warnings to the emergency authorities are usually accompanied by a Press release to all parts of the media and special emphasis is given on all routine weather forecasts. Nearer to the event, typically within 12 hours, 'FLASH' warning messages are issued giving as much detail as possible about the areas to be affected and the likely severity. The media have responded well to this open approach and have made special efforts to highlight impending severe weather.

The floods at Towyn

These situations are tricky to deal with meteorologically and there is always an element of uncertainty. Nevertheless the Office exercises its best professional judgement and did particularly well over the last year.

The winter of 1990/91 ended the succession of mild winters. The snow on 8 December which led to severe traffic disruption (with cars abandoned on the M5) was also well forecast; it was the rate of accumulation of snow and its wetness which made it difficult for councils to keep the roads clear. Several days advance warning was given of the exceptionally cold spell in the second week of February 1991. Temperatures in the day-time were below freezing point in many areas, and overnight fell as low as –15 °C (5 °F) in places. With such low temperatures the snow was extremely fine and powdery — easier for road clearance but causing particular problems to British Rail by infiltrating the traction equipment.



Storm Tide Warning Service

Since the Storm Tide Warning Service started, our understanding has improved and it is now possible to provide good forecasts of 'storm surges' in which the wind drives water into the confined area of the North Sea. Information is passed daily to the relevant authorities, and warnings are issued when danger levels are likely to be exceeded. The Service also provides information for closing the Thames barrier.

Despite improvements in coastal defences, there is still a need for this service — emphasized by flooding in north Wales in February 1990. The high water levels, aggravated by wave action, were well predicted. Indeed the report of the Welsh Affairs Committee which investigated the breach of sea defences described the surge forecasts as 'surprisingly accurate'.

Shipping

Shipping forecasts and gale warnings are a long-established part of the Public Meteorological Service. The Safety of Life at Sea convention lays down clear obligations on the United Kingdom as one of the contracting governments. Shipping forecasts are provided four times a day and North Atlantic bulletins (out to longitude 35° W) twice a day. Gale and storm warnings are kept up to date continuously. There is close collaboration with the shipping community and it is worth noting that ships provide a valuable source of observations for meteorology.

Map of shipping forecast areas.

Pollution emergencies

Weather advice is an important component in dealing with pollution incidents. In the event of a release of toxic chemicals or radioactive material, advice can be provided speedily to those in control of the situation. There is a weather dimension too in forecasting the movement of oil slicks; forecasts of winds and waves are provided to the Marine Pollution Control Unit. This year assistance was provided further afield, for the Gulf area and for the Italians dealing with a major spillage in the Mediterranean.

Weather information for the public

There is an avid demand for weather information and the Office makes this widely available through television, radio, teletext, the Press and telephone. The media are becoming increasingly keen to upgrade their presentations; as a result, many media services are provided on a commercial basis. It is a fact that on many evenings more people watch the weather forecast on television than watch the evening news. During the year a new air-quality service was launched in collaboration with the DOE and Dept. of Health.

Civil Aviation

During the year, the Office continued to work closely with the Civil Aviation Authority (CAA) — the delegated authority for meteorological services to aviation in the United Kingdom — and the International Civil Aviation Organization (ICAO) — who control services for international commercial aviation.

Montreal conference

In September, delegates from the Office attended an international conference, organized by ICAO and the World Meteorological Organization (WMO), whose objective was to set standards and agree policy for improving meteorological services to aviation during the next decade.

Boeing 757 of British Airways taking off from Heathrow.

As a result of the conference, agreement was reached on a wide range of substantive issues. For example, the current *Standards and Recommended Practices* will undergo a major revision. Major changes to the codes for aviation reports, which had been proposed by WMO, will be implemented by July 1993.

The two World Area Forecast Centres (WAFCs) at Bracknell, United Kingdom and Washington DC, USA will be maintained and have been tasked with developing the capability of producing automated global significant weather information. (This has already been demonstrated within the Central Forecasting Office at Bracknell.) Full advantage will also be taken of new global forecast models being introduced at the WAFCs to improve the horizontal and vertical representation of global wind and temperature data used for flight planning .

Flight safety was an important issue at the conference. Discussions covered ways of improving warnings of hazardous weather, issuing advice on volcanic ash clouds, and improving forecasts of the risk of ice formation on aircraft through the use of liquid-water-content forecasts. Services for offshore operations should also be improved.

Reservations were expressed over the validity of introducing a fully automated observing system on aerodromes, but agreement was reached to allow semi-automated systems to be acceptable. Finally, a study group is to be set up to consider all aspects of the automated observing systems now being fitted to many aircraft.

General aviation services

The Office and the CAA have also been looking at ways of improving information services to General Aviation. Regional forecasts were modified and a standard vocabulary is now used to describe the various elements.

The Office also developed an automated facsimile service for aviation users, and consideration was given to replacing the present system.

Training of Air Traffic Control staff took place at Stansted Airport to enable a trial of the Semi-Automatic Meteorological Observing System, developed within the Office. The feasibility of making weather observations while employed in their other duties will be assessed.

SAMOS — the Semi-Automatic Meteorological Observing System — records and encodes those elements of an observation that require no particular skill or subjective assessment, so saving valuable staff-time.

Research

Research projects continued to be supported. Hindcast information was supplied for several accident investigations and studies were made of headwind forecasts for long-haul flights arriving over the United Kingdom with minimum fuel reserves. At Gatwick a study was completed which assessed changes in wind along the runway; this showed the need for a second anemometer system.

During the winter, forecasts of liquid water content over the North Sea were supplied for assessment by forecasters and helicopter crews.

During September a correction scheme was applied to the aviation wind forecast products generated by the numerical weather prediction output. This had a marked effect in those areas of the globe where strong winds occur. The improvements were immediately noticed by the airlines in their flight planning and were welcomed.

Defence

Meteorological services for Defence remain a key activity for the Meteorological Office as an Agency. About a quarter of the Office manpower directly serve military customers. The Defence requirements are reviewed within the Defence Meteorological Group (DMG) of the MOD which is the interface between the Office and the customer. The quality of service is monitored through regular assessments. Customer surveys and objective assessments indicate that the standards set by the DMG at the beginning of the year were met or exceeded.

The Senior Meteorological Officer at RAF Cranwell demonstrates ODS for AOC (Training Units), Air Vice Marshal M. J. Pilkington CBE RAF (seated).

The Principal Forecasting Office (PFO) at Headquarters Strike Command (HQSTC), backed by computer predictions from the Central Forecasting Office at Bracknell, provides the basic support for services that are provided from offices on Defence establishments. This on-site presence guarantees close liaison and services tailored to local needs. There are over 40 offices in the United Kingdom, 6 in Germany and single offices in Gibraltar, Cyprus, Ascension Island and the Falkland Islands.

Nine new automated computer-based display systems (ODSs) were installed during the year and 17 installations upgraded. ODSs provide fast access to a range of weather information, including radar–rainfall pictures and satellite imagery, in a form suitable to the forecasters' needs.

A MIST display of station 'colour states'. The colours give a coded representation of weather conditions.

Forecasting for military aviation remains the prime Defence Services task and during the year about 300 000 weather briefings were given. Low-level flying is particularly weather sensitive and aviators require detailed information of the weather expected during all phases of missions.

During the year, trials at RAF Marham of MIST, the Meteorological Information System that enables incoming information and locally prepared weather products to be automatically disseminated and displayed on a colour graphics terminal, were successful.

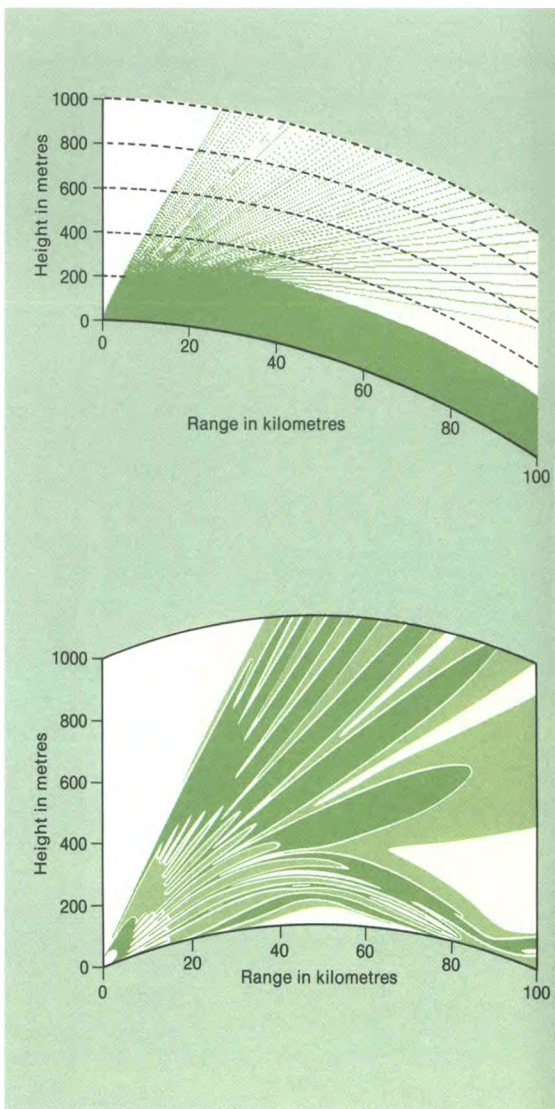
Office staff continued to provide meteorological instruction to military aircrew. RAF Air Traffic Control staff and Royal Navy

Flight Controllers were also instructed in the interpretation of meteorological data. In excess of 4000 man-hours tuition were provided this year. With the introduction of the Tucano trainer aircraft, the syllabus and method of teaching have been revised.

Military Range offices were equipped with a new radiosonde system that provides temperature, humidity and wind measurements up to about 70 000 feet. The system is simpler to operate than its predecessors and more efficient, so helping to reduce running costs.

Range stations require noise forecasts to help minimize disturbance to the public, whilst ensuring optimum use of the range. A prototype of an improved acoustic model is now ready for testing, and validation trials will take place at Shoeburyness.

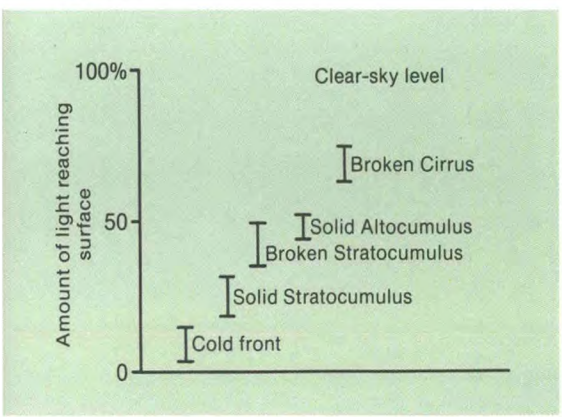
Forecasts of atmospheric radar ducts are now produced by the PFO at HQSTC on trial and are being evaluated jointly with the RAF. Close liaison has been maintained with the Rutherford Appleton Laboratory (RAL) who have been developing improved propagation models for calculating the radar coverage.



Radar coverage diagrams from the current operational model (above) and the new RAL model (below). Note the improved detail at low levels.

Forecasts of night illumination are made regularly at many outstations on RAF and Army airfields, and trials to assess the effect of cloud in reducing the light level were held. The results showed that cloud can attenuate the light level to less than 1/10 of the clear-sky value.

Typical amounts of light reaching the surface as measured in trials for different cloud types and amounts.



The Defence Services Division continued to provide support to NATO with representation on a number of committees and working groups. Support was also supplied to the emergency services. Plans to provide meteorological advice following an accidental release of hazardous material into the atmosphere were updated to reflect improvements in the Office's specialized numerical prediction methods.

The Gulf War

The Met. Office response to Operation Granby (the British military operation in the Gulf) was swift and effective with many Defence Services meteorological offices, both in the United Kingdom and overseas, becoming quickly involved in providing forecasts and climatological advice.

Tornados after returning from active service in the Gulf area.

The Principal Forecast Office (PFO) at Headquarters Strike Command (HQSTC) played a major role in providing the meteorological services required by the military.

An Operation Granby meteorological support cell was established in the PFO during early August 1990 and, for the period of active involvement of UK forces, senior staff at HQSTC worked roster duties to co-ordinate the increased meteorological input to operations — daily in excess of 70 forecast tasks. In addition to the Joint Headquarters, support was provided to the Joint Operations Centre at MOD, Support Command and RAF Germany, HQ British Forces Middle East and 4 and 7 Armoured Brigades.

Many offices at RAF and Army bases in the United Kingdom and Germany were actively engaged in the build-up phase. The Main Meteorological Office at Akrotiri provided forecasts for aircraft using the base as a staging post.

In March the C-130 aircraft of the Met. Research Flight was dispatched to the Gulf where it flew for 55 hours, obtaining the world's first airborne measurements of chemicals, particulates and radiation within the plume.

In-theatre support was provided by the Mobile Meteorological Unit (MMU) whose members are Met. Office volunteers holding active Commissions in the Royal Air Force Reserve of Officers or Royal Air Force Volunteer Reserve. The MMU was deployed in early December with three support staff later added to the initial detachment of three forecasters.

Climatological data and the effect of weather on military operations and equipment were frequently requested during the build-up phase. A booklet entitled *Climatic tables of Arabia* was produced and distributed to many MOD operational and ordnance agencies.

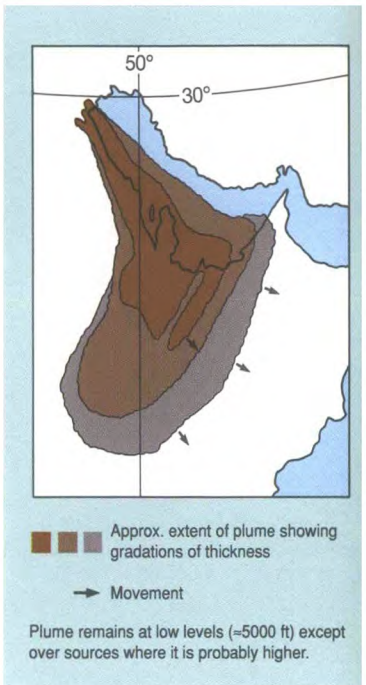
Computing facilities were quickly made available for operational runs of the numerical weather prediction high-resolution model centred on the Persian Gulf, and

additional Global Model output provided. Also a very-high-resolution (approximately 10 km) Mesoscale Model was centred on the region. The low-level wind forecasts proved particularly useful. Images from the geostationary satellite (Meteosat), as well as additional satellite pictures and facilities, provided valuable information over an otherwise data-sparse area.

The dissemination of products and data required new communication links and expansion of existing facilities, requiring much effort and some ingenuity.

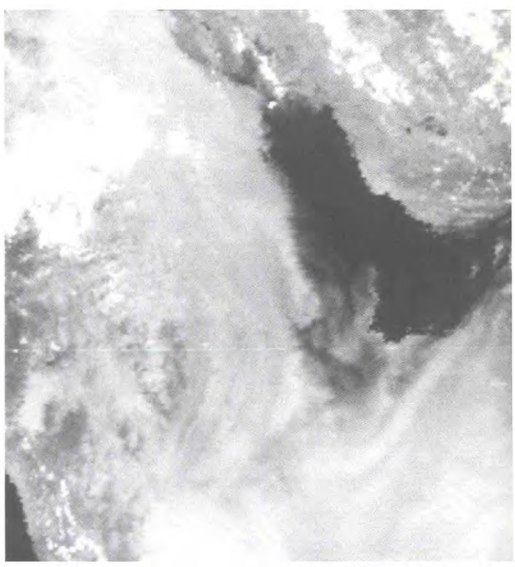
The MMU, the PFO at HQSTC and the outstation forecasters were at the forefront of the campaign, but many other staff contributed to the operation and had to cope with increased workloads and pressures.

In December 1990, the Department of the Environment asked the Office to investigate possible environmental consequences should the oil wells in Kuwait be ignited. Pre-war oil production figures formed a useful basis for our assessment; accurate emission figures are still awaited.



Subjective assessment, using all available data, of the extent of the plume shown below.

Calculations, verified by observations, showed that the pollutants would generally remain within the lower troposphere. Therefore, smoke would be deposited on the ground after a week or so and the worst effects confined to the Gulf region. The Climate Model indicated a possible slight enhancement of the Asian summer monsoon precipitation, but this is likely to be small compared to natural variability.



Meteosat visible image for 1200 UTC on 23 February 1991 showing smoke drifting south-eastwards away from Kuwait.

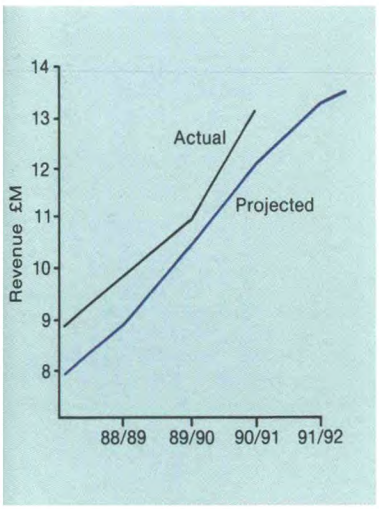
Close to the oilfields, calculations indicated a reduction in daylight to near night-time levels under the plume and a mid-day temperature reduction of some 10 °C within about 200 km of the source. Also, oxides of sulphur and nitrogen in the plume will cause isolated episodes of very acidic rainfall and, on higher ground, soot deposits within the snow. Such events may occur out to 2000 km from Kuwait, occasionally further. These predictions were subsequently confirmed by observations.

A report on these predictions was lodged in the House of Commons by the Secretary of State for Defence on 17 January 1991.

Commercial services

Our targets as an Agency are to build on our unique assets to service an increasingly broad commercial customer base. The benefits of using accurate weather forecasts, generated by sophisticated numerical models, are now beginning to be widely perceived by the business community as an effective component of decision-support systems.

We are also now increasingly sensitive to customers' needs; needs which must be detected and assessed. Products must then be tailored to fit, and delivered by the most appropriate means. After delivery, their quality must be continuously assessed. We have been developing techniques this year to obtain more comprehensive and systematic feedback from our key clients on their level of satisfaction with our services.



Sales of over £13 million represent a growth of 17% on last year.

During this financial year these needs were addressed more effectively by introducing a fundamentally new structure. All the revenue earning sectors were brought together under one newly appointed Director of Commercial Services and a newly created Board of Directors. The Directorate now employs 640 staff engaged on market research, product marketing, marketing communications, commercial product development, production, service provision, quality control and sales to the commercial sector. They also contribute to services to the CAA and the Public Met. Service, and assist in making and collecting observations.

The number of Sales and Marketing staff has now increased; market sector managers are responsible for sixteen vertical markets, such as agriculture, offshore operations, land transportation, energy and water services, shipping, media, etc. Business units service the special needs of the retail and distribution sector, and TV and radio broadcasting.

A continuing programme of training supplemented the reorganization, to bring our staff up to speed on sales and business disciplines. New financial and management information systems are being introduced to measure profitability of market sectors, products and cost centres and their contribution to core costs. This will enable us to set priorities and improve financial management.

Local authorities can save an average of £10 000 on each salting run, and stocks can be optimized using accurately forecast temperature trends.

Product marketing in the Office consists of exploiting the vast range of data, information, experience and technological resources at the centre of our operation, and presenting data which the customers need on time, and in a readily acceptable form. Increasingly, the method of delivery is becoming a crucial factor as information technology progresses, a subject which has received particular attention during the year.

'OpenRoad', a service forecasting the locality of severe road conditions, enabled an international haulier to stay operational during the winter snowstorms.

An important innovation in delivery techniques is automated facsimile transmission. For example, 'Weatherfax', a new service introduced in 1990, can provide hourly updated information on users' fax terminals. Its first applications have been in agriculture, but plans to provide an integrated package, including the fax machine, through co-operative marketing agreements with manufacturers, may broaden the appeal. Dial-up fax offers opportunities for the future, and services based on this technology will be introduced in 1991/92.

The 200 dpi resolution is good enough for a fax transmission to be used directly as newspaper artwork, after reduction.

The speed and efficiency of broadcast fax has become instrumental in the distribution of severe weather warnings to local authorities, shipping and ferry operators and potentially every customer and client. The Press is already well served by charts transmitted by fax, and during this year, we have progressed further towards electronic transmission of ready page make-up to newspapers.

Delivery of weather and climate information through personal-computer (PC) networks also expanded. For example, trials were carried out on the MIST system with some of our offshore clients. MIST delivers continuously updated data from our central computer directly to users' terminals, where they can select and manipulate the displays.

It is also the timeliness of information transmitted directly to PC networks that has helped us keep up our standards of service for the local authorities' frost warning services. During the winter of

1990/91, the Met. Office achieved an accuracy of 85% in frost warnings, significantly better than competitive services, and in line with our quality targets. This, together with the introduction of road-surface-temperature monitoring, will continue to produce major financial savings for local authorities and improvements in road safety.

International Weather Productions retained the ITV contract to provide services until the end of 1992.

Premium-rated telephone services, delivered in conjunction with Telephone Information Services, continued to yield substantial revenue, and an important new branded service, 'Audiocall', was introduced in conjunction with the BBC.

We also shifted into a higher gear with our public TV services. International Weather Productions (IWP) — the Met. Office unit providing services for commercial television and now located in WTN's purpose-built integrated unit at The Interchange in Camden — is able to provide almost any level of service for franchisees, from training of staff, through provision of graphics or data, to complete productions. IWP's international operations are now expanding. Already, data are supplied to CNN, the US news channel, and pilot services have been requested by a growing number of overseas channels.

Consultancy from The Weather Initiative can save retail chains well over £300 000 a year in purchase of stocks.

Our BBC team is also preparing to move into new studio facilities at BBC TV Centre, White City. From there, a new business unit will handle all BBC TV and national radio weather broadcasting. The BBC unit is also expanding its international business with the launch in April 1991 of international weather services for the new BBC World Service Television network.

At the beginning of the financial year, we launched The Weather Initiative (TWI), a consultancy service aimed at helping managers in industry identify and exploit the sensitivity of their business to the weather. Increased profits were achieved by TWI's clients, by being able to make informed

Contingency planning and scheduling of major construction projects such as the Channel Tunnel are facilitated with 'SiteWise' forecast data.

decisions on how the weather can affect sales volumes and hence optimizing the purchasing of stock, scheduling of manufacturing processes and advertising campaigns.

Fragmentation of the electricity and water industries, due to privatization, has created many new potential customers for the Office, requiring a wider variety of services. Our continued strong relationships with British Gas, National Rivers Authority and the National Grid is a result of our being able to meet their exacting standards of accuracy, timeliness and verification of forecasts.

It is our emphasis on market research — quantifying changes in existing markets and identifying new ones — which is instrumental in the success of the many new products we have introduced during the year. For example 'SiteWise', our tailored service for the construction industry, has seen a major increase in demand this year. Knowledge of the prevailing conditions in areas of planned development provided by 'SiteWise' is invaluable for contractors when costing estimates, scheduling work and making contingency plans. And it is the increased attention paid to efficiency and automation in production that has enabled us to deliver these services at a competitive price.

Accurate forecasting of rainfall trends saved one River Authority £780 000 in power consumption of pumping equipment.

A particular strength of the Met. Office is its representation through regional weather centres, who can overlay local conditions and experience on the general data provided from the centre. This prompted the move of the oil bench from London to the Aberdeen Weather Centre, utilizing its local knowledge to support the offshore oil industries, and being closer to its client base, providing a more economic service. Our extensive use of high technology made a move necessary this year into new premises for the Newcastle, Plymouth and Birmingham Weather Centres, and as a bonus has made Met. Office services more readily accessible to our customers.

There is still massive scope for industry and commerce to improve their financial performance, operational safety, and competitive edge by using quantitive weather data. We are therefore confident that the substantial growth we have seen in our business this year will continue despite the effects of the recession. This, coupled with improvements in efficiency, will yield significant increases in contribution to core costs in the year ahead.

Central support

The work behind the scenes

Before Ian McCaskill appears on the television screen, before the off-shore oil-rig is warned of the impending storm and before the world's airlines calculate the best route based on the jet stream forecasts, there has been a massive effort behind the scenes from meteorologists both in the United Kingdom and abroad. Observations have been made by a variety of methods including satellite, aircraft, ships and radar. All these observations have been transmitted electronically and fed into the telecommunications centre at Bracknell. After rigorous quality control process, the complex numerical weather-prediction models, running on Cray supercomputers, take over. These computer models of the atmosphere provide many results for the forecasters to study, modify and interpret them. Not that they have long; the customer needs timely, as well as accurate, weather information.

The Cray YMP supercomputer.

Observations

For dedicated national use the Office maintained this year nearly 300 synoptic stations over and around the British Isles. About 60 are fully automated and a further 150 are manned by auxiliary observers (coastguards, oil-rig personnel, etc.) whose efforts in producing current weather information are greatly appreciated. At the 80 officially manned stations a five-year programme of automation is in hand to minimize the human effort needed while maintaining or improving, as necessary, the synoptic network.

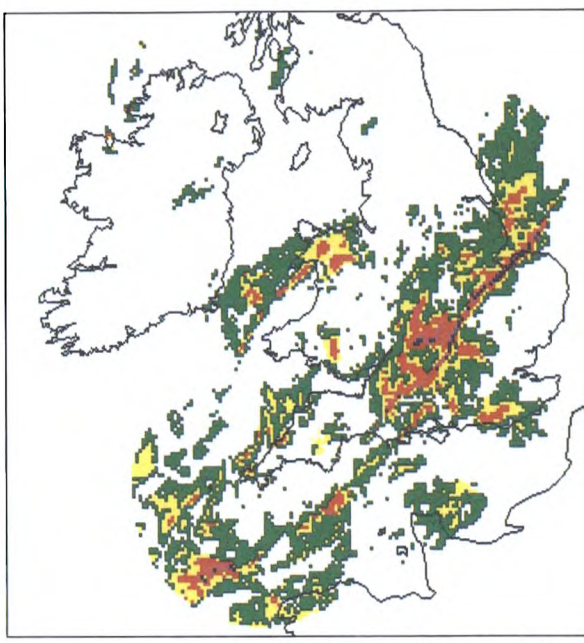
The Office gratefully acknowledges the crews of over 500 UK recruited ships and rigs that in 1990/91 formed part of the 7000-strong international voluntary observing fleet of 49 countries. Another very important contribution to observing over the oceans is the Met. Office weather ship that patrols to the west of the British Isles. Observational gaps over the sea are filled by moored and drifting buoys as part of international programmes.

The Office maintained an eight-station UK balloon-borne radiosonde system, now updated with modern technology, and a further three sites overseas. Radiosonde ascents are also made from a merchant ship trading from the United Kingdom to Canada. Aircraft reports of wind and temperature also provide useful data and the first production models of a dedicated aircraft-to-satellite relay system are now flying on civil wide-bodied jets.

Muckle Flugga, the northernmost inhabited island of the British Isles, part of the auxiliary observing network.

The weather-radar network continued to expand during the year with the opening of the States of Jersey radar, and four new installations, including three in Scotland, in varying states of progress. As well as aiding forecasters, data from the network are fed to the National Rivers Authority for river management and flood warning purposes.

A unique long-range detection system locates thunderstorms over the western Atlantic, the eastern Mediterranean and even further afield. The system uses the difference in time of arrival of the radiation from lightning flashes to locate the position of the storm.



Radar composite of rainfall rates, showing a surface cold front marked by a very narrow belt of heavy rain (magenta and blue).

The Office contributes to the European geostationary satellite Meteosat and provides instruments to the US polar-orbiting satellites. During the year, plans were developed for the next generation Eumetsat space satellite and development continued of the AMSU-B instrument to fly on a US polar orbiter.

Support is given to a 500-strong voluntary climatological network and a 4000-strong rainfall one. The work of these dedicated observers augments observations from Office-manned stations and forms a valuable part of the National Archives.

Telecommunications and Computing

Telecommunications facilities play a key role in two main parts of the overall weather forecasting system: firstly in ensuring that observational data, both from within the United Kingdom and from the rest of the world, are made available accurately, promptly and reliably and, secondly, in delivering forecast products to customers.

It follows that very high reliability is a key performance indicator for routine telecommunications services. The second target is to improve the cost-effectiveness of telecommunications, partly through automation. In 1990–91 the reliability target was met and the cost-effectiveness target was comfortably exceeded owing to decreased costs and increased services and throughput. Further investment in 1991–93 will be followed by a period of significant improvements in performance against targets.

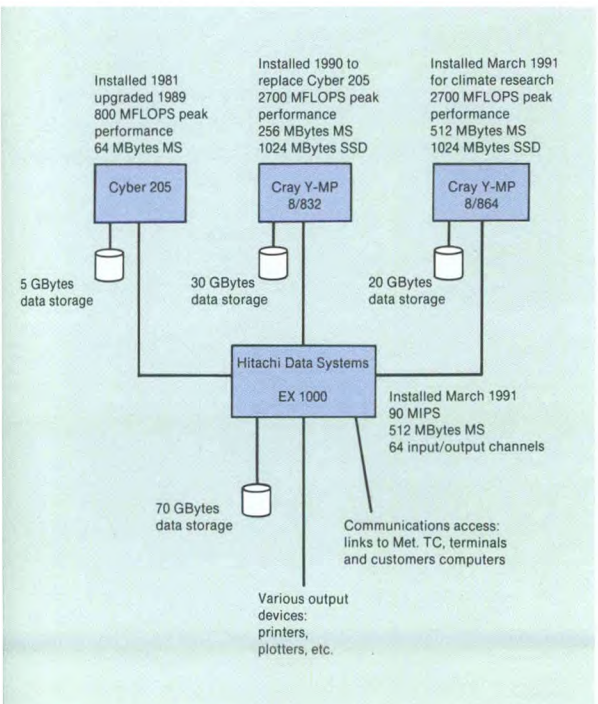
Central Computing provides the resources for many activities in the Office which rely on large databases or large amounts of numerical work. Major changes have taken place this year in the facilities provided. A Cray YMP8 computer, with 8 processors and 64 million words of main memory, was installed towards the end of the year. This machine was funded by the contract for climate studies awarded to the Meteorological Office by the Department of Environment.

The IBM 3084, which provided the general computing service and acted as a front end to the Cray YMP8 used for the Meteorological Office, was not adequate to support two Cray YMP8s. The 3084 was therefore replaced by an EX-100 obtained from Hitachi Data Systems.

Despite the major changes to computing facilities, targets for service and availability were met in most months. It has not been possible to relate the measurements of cost and performance across this major change, and new baselines for assessment of cost/performance are now being established.

There are a number of active projects involving automation. The Systems Development Branch is dedicated to such projects but similar work is also undertaken in a number of other branches. Performance on these projects is assessed by progress against milestones and completion within the budget.

COSMOS configuration



Projects deserving special mention this year include:

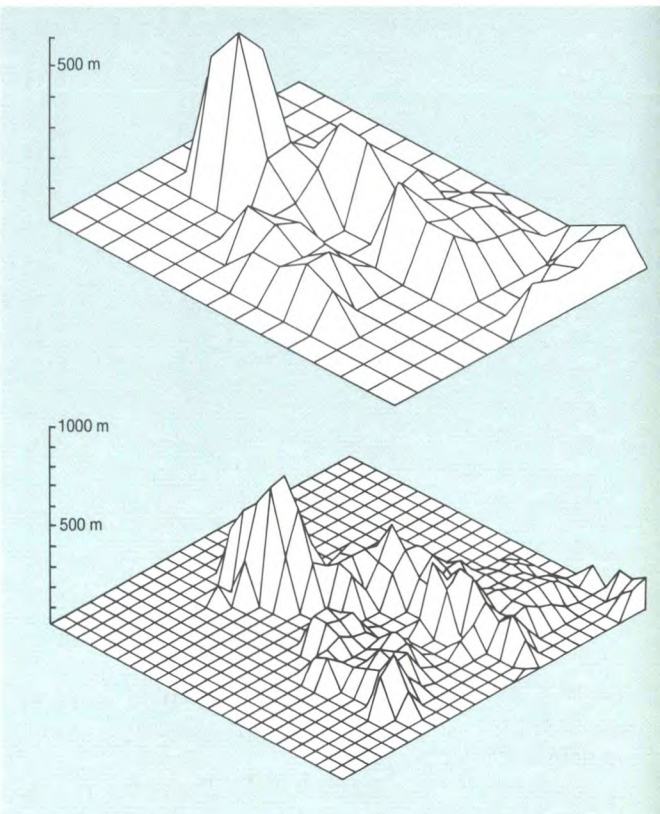
- outstation display systems (ODSs) designed to provide more information in a timely fashion to weather forecasters in the outfield and to avoid replacement of expensive obsolete equipment; ODSs have now been upgraded to handle high-resolution imagery such as satellite pictures;

- MIST, a low-cost system aimed at providing weather-related information; prototypes are now working to serve both military and civil aviation.

Central Forecasting

Central Forecasting's task consists of two main functions — firstly to maintain the vast body of computer programs making up the operational numerical weather prediction suite and secondly to give guidance on the weather developments to all the Met. Office centres around the country.

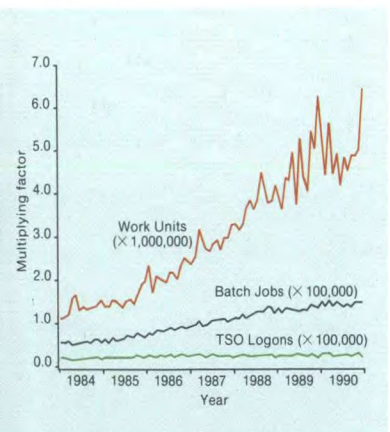
The main changes in the operational numerical model suite this year have been to extend the range of output available to both the forecaster and to external customers. Development effort has been concentrated on bringing the next-generation model to fruition. As computers have become faster, the results from numerical models have become more accurate. The new model will run on the Cray YMP; it will have over a million grid points but a 24-hour forecast will still only take about five minutes of computer time. Extensive development and operational testing during the year suggest that the new model will fulfil expectations. Implementation is scheduled for June 1991.



Model orography: views north-eastwards across the British Isles in the global (above) and limited-area (below) versions of the new Unified Model.

The Central Forecasting Office (CFO) is the hub of the Office's forecasting activity. Although it is a major team effort, the buck stops with the duty Chief Forecaster who has the responsibility of setting down the story to be followed by all the offices around the country. There were several occasions to test his mettle, from the severe storms in early 1990 to the disrupting snowfalls of the recent winter (see the section on the Public Meteorological Services).

One major new project began during the year — to provide much more powerful graphics devices in the CFO. These will enable the forecasters to have faster and more flexible access to all the information they need and the ability to produce graphical output. With a much greater degree of interaction, the aim is for the CFO to provide a higher quality service (in terms of content, presentation, accuracy and speed) and to provide it more efficiently.



Computer power (Work Units) has escalated to meet the demands of increasingly complex forecasting tasks (Batch Jobs and TSO Logons).

Research

Climate Research

Scientific, political and public interest in the climate continued throughout the year. The new Hadley Centre for Climate Prediction and Research combines two major research programmes, a new Climate Prediction Programme funded by the DOE and the established climate research programme funded by the MOD. During the year staff numbers increased to about 90.

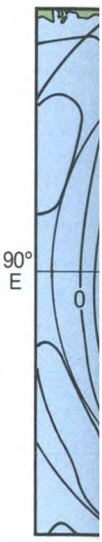
The former Prime Minister, the then Rt Hon. Margaret Thatcher, MP, opening the Hadley Centre for Climate Prediction and Research on 25 May 1990.

The Office made three major scientific contributions to the Intergovernmental Panel on Climate Change (IPCC) Report. First was the analysis of the observed record of surface temperatures which has been a major part of the Office's research for many years. The value of this work has become increasingly obvious as the expectation has grown that climate change is occurring due to increasing greenhouse gas concentrations, and as the evidence for actual change has accumulated. Monitoring by the Office in collaboration with the Climate Research Unit at the University of East Anglia shows that 1990 was the warmest year in the global record that started in the mid-19th century.

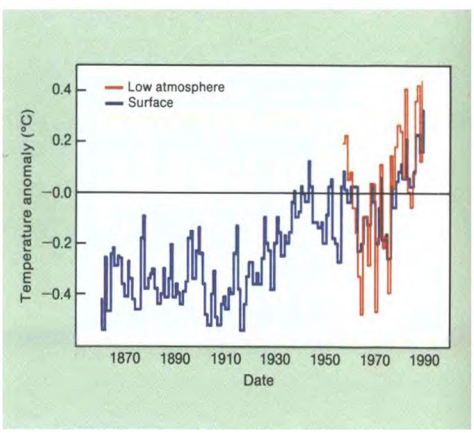
The other major contributions to the IPCC assessment were on the application of numerical models to the problem of predicting the equilibrium effects of increased greenhouse gases, and on the validation of the models used in such predictions. The Office also provided one of three predictions which were adopted as the basis of the Report's estimate of climate change into the 21st century.

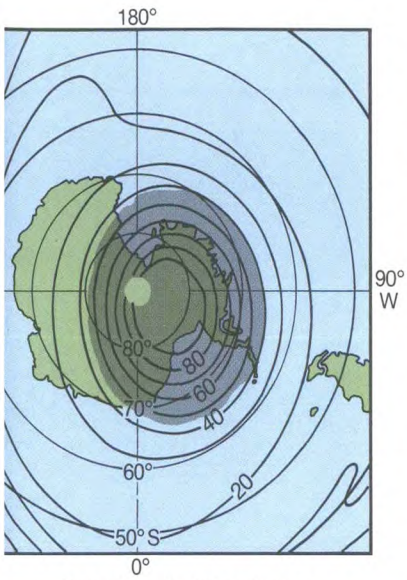
Most experiments to predict climate change have so far used atmospheric models coupled with simple, shallow ocean models to ascertain the equilibrium effect of, say, doubling CO_2. However, it has long been realized that to obtain detailed advice on the evolution of climate change, coupled models of the atmosphere and deep ocean are required which must be integrated over periods of many decades while greenhouse gas concentrations are increased gradually. By including a deep ocean and a gradually increasing greenhouse effect, more accurate and relevant predictions of climate change can be obtained.

However, the available computing resources were not sufficient for such experiments. Hence, the DOE funded a dedicated supercomputer for climate-prediction research,



Global mean temperature anomalies (°C) from the 1961–90 mean for surface (land + ocean) and low atmosphere (850–300 mb).

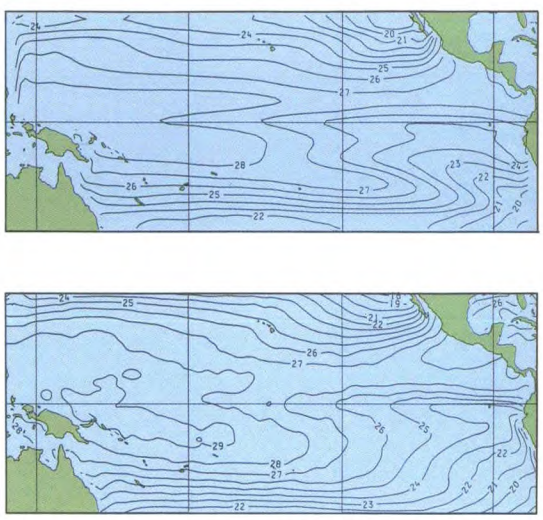




Percentage depletion of ozone, relative to the amount predicted for transport alone, at 75 mb for the most intense phase of the modelled ozone hole. (Shading indicates where chemical reactions have occurred on polar stratospheric clouds.)

which will come into use in April 1991. While the new facilities were being established, the existing climate model, which includes a deep ocean, was used to carry out our first experiment with gradually increasing CO_2. This model is of higher resolution than those used for earlier experiments elsewhere.

A number of new developments are being introduced in the models. The IPCC assessment emphasized the uncertainties due to clouds in estimating the greenhouse warming; the new unified model offers greater flexibility in the representation of clouds. Accurate simulations of the climate near the surface are essential; improvements in this area include allowing for the great heterogeneity of the land surface and developing new representations of hydrological processes, in collaboration with the Natural Environment Research Council's Institute of Hydrology.



Annual average sea surface temperature (SST) computed from the Met. Office coupled tropical Pacific global atmosphere model (above) compared with the climatological annual mean SST computed from historical data (below).

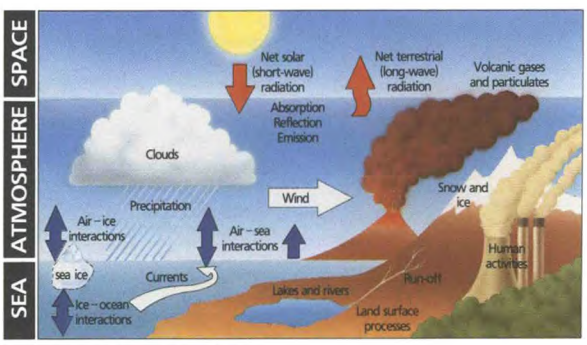
The tropical ocean is recognized to have a major role in variations of climate both within and outside the tropics; this gives them value for seasonal forecasting, particularly within the tropics. A 15-year experiment was completed with the coupled model of the tropical Pacific and the global atmosphere which gave an encouragingly realistic simulation of the mean ocean state. However, attempts to simulate the major observed variations of Pacific Ocean temperature were unsuccessful.

Modelling of upper regions of the atmosphere is essential if the effects of human activity on the ozone layer are to be understood and predicted. One version of the new Unified Model has been designed to use the data to be obtained from the Upper Atmosphere Research Satellite (UARS) (to be launched later this year) and includes a detailed representation of the stratosphere and lower mesosphere. The model used for many years to study the stratosphere and mesosphere independently of the troposphere will still be available; recently it was used to simulate the chemistry involved in the development of the ozone hole

Increased realism in climate simulations requires additional processes in the models. To accelerate these, collaborative projects were set up with institutions in the United Kingdom and abroad. Some of these involve contracts placed under the IPCC, whereas others are projects of mutual scientific benefit to all the institutions involved, in some cases with support from EEC funding.

Research into improved forecasting

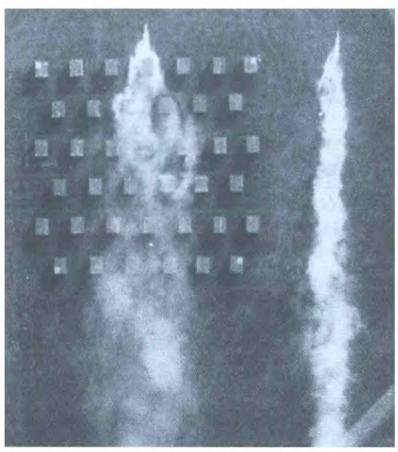
The primary target during 1990 was to develop and test the Office's new numerical model for weather prediction and climate research, the so-called Unified Model. Hitherto, the different needs of weather forecasting and climate research have demanded different kinds of model, the former employing simplifications in design and very fast computational methods and the latter emphasizing the coupling of component parts of the climate system (atmosphere, ocean, ice and land surfaces). However, the need to include representations of weather phenomena in greater detail in both operational forecasting and climate models has led to a merging of requirements — a unified modelling facility can now be used for both purposes.



Schematic picture of the component parts of the new Unified Model for weather prediction and climate research.

The Unified Model is extremely versatile; the atmospheric and oceanic components can be coupled or run independently; the domain can cover the entire globe or a limited region; observations can be assimilated to provide analyses of variables at fixed times; and grid resolutions can be suited to particular applications. Tightly controlled project management, with emphasis on programming standards and quality assurance, was essential to complete the writing of the computer code for such a broad set of requirements within a short time-scale. The first version of the atmospheric model was available on 1 April 1990 and routine operational trials began in November.

Smoke plumes passing over flat ground and through an array of obstacles, showing the effect of a group of buildings on plume dispersion.

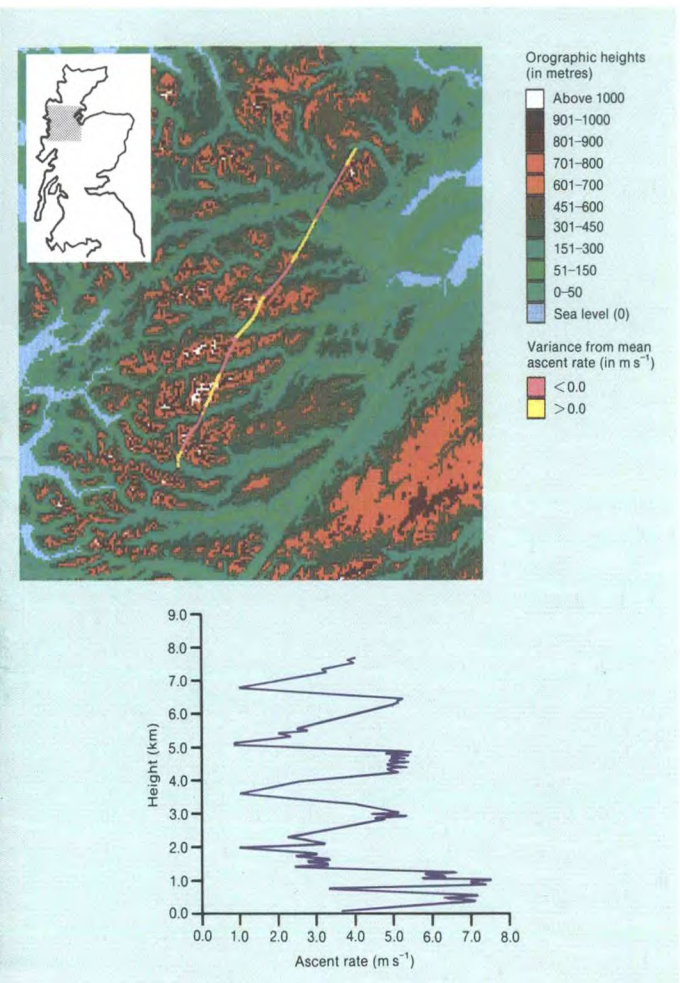


Expansion of research on the use of space-based observing systems reflects their greater importance during the coming decade. Temperatures in the vicinity of the British Isles deduced from satellite radiance measurements are now making improved contributions to the accuracy of forecasts, especially in summer; the use of radiances themselves (instead of temperatures inferred from them) will soon be tested. Preparations are advanced for routine trial applications of observations (surface winds, ocean waves, sea surface temperatures) from a variety of instruments on the ERS-1 satellite.

During the year new satellite imagery products were developed for the Autosat-2 system; these are now available to forecasters. Techniques were also developed for producing composite rainfall distributions over Europe derived from a variety of sources (satellite imagery, radars, graphics and model predictions).

Physical processes in the atmosphere

Experimental and theoretical studies of physical processes in the atmosphere are required to enable the development of better weather forecasting and climate models and the provision of advice on topics such as atmospheric dispersion of toxic or radioactive materials.



In addition to the observational facilities use is also made of high-resolution numerical models. Numerical simulations of three-dimensional turbulent flow over hills were completed and the above (top) shows the trajectory of a radiosonde launched from Loch Cluanie on 12 November 1990 plotted on a terrain-height map. Yellow sections of the trajectory indicate rising air and pink sections sinking motion. The rate of ascent of the sonde plotted versus height is shown (below).

Studies with the Office's main experimental facility, a C-130 aircraft, were concerned with the structure of weather systems, the properties of clouds and with radiative transfer in clear air. A major effort was the analysis of cirrus-cloud data obtained in the International Cirrus Experiment. The data will be used in weather forecast models and for improved algorithms for the interpretation of satellite instruments. Atmospheric chemistry measurements should help in the development of improved models for the sources and sinks of greenhouse gases such as methane.

A tethered balloon, based at Cardington, is concerned with studies of the turbulent flow in the lowest kilometre of the atmosphere. Measurements with instruments carried by this balloon and also radiosonde data were used to provide improved representations of the momentum transfer in mountainous areas.

Experimental studies of atmospheric dispersion continued; and recent advances are being incorporated into a general purpose dispersion model being developed jointly with Cambridge Environmental Research Consultants and National Power. To assist in the national emergency response, a longer-range numerical model for predicting the transport and deposition of radioactive material has been completed.

Other models seek to explicitly describe the turbulent motions. These 'Large Eddy' models were reformulated and will be used for development of descriptions of the turbulent flow near the ground.

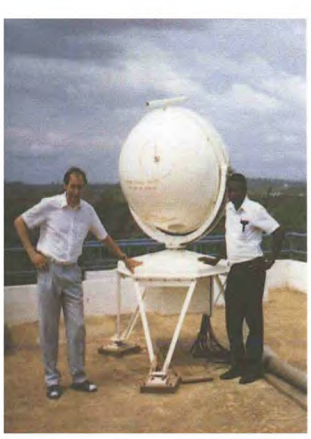
International

On the international scene it was a busy year for the Office, and one dominated by the climate change issue. Drs Houghton and Jenkins were members of the UK delegation to the ministerial part of the Second World Climate Conference held in October while several other staff members participated in the scientific part. The Conference recommendation for a Global Climate Observing System was developed further when the Office hosted an international meeting in January 1991.

The Commission for Basic Systems conference held in London during the year at which the Office played a leading role in the debate.

Of all the WMO meetings, those of the Commission for Basic Systems are the most important for the Office. It is here that all the practical details of international co-operation in the implementation of the World Weather Watch are worked out and agreed.

During the year Office staff also attended regional meetings (Europe and Africa) of the Commission for Atmospheric Sciences. The United Kingdom belongs to the latter by virtue of the observing programme on St Helena. However, the main advantage in attending is to learn more about the problems of African National Meteorological Services with a view to providing assistance under the Voluntary Co-operation Programme (VCP).



The newly installed Siemens Plessey WF33 wind-finding radar at Accra, Ghana; part of the United Nation's contribution to the WMO Voluntary Co-operation Programme.

The year's major activity under the VCP was the refurbishment of wind-finding radars at upper-air stations. Radars were installed at Accra, Ghana and Rodrigues, Mauritius. An evaluation was made on the use of the satellite communication facilities of Meteosat to improve telecommunications in Africa. The receipt at Bracknell of Ghanaian observations improved considerably after UK donations of equipment to Ghana.

On the European scene there has been greater emphasis on European co-operation. Participation continued in the European Centre for Medium-range Forecasts and in EUMETSAT. The latter is in the process of expanding its programmes to provide a continuation of the operational European geostationary satellite system into the next century.

Through the informal conference of Directors of western European National Meteorological Services, new initiatives were taken to increase co-operation between the Services themselves, specifically in the fields of climate research and the provision of commercial services. The latter topic featured prominently at a meeting hosted by the Office in February 1991.

Finance

INCOME AND EXPENDITURE ACCOUNT for the year ended 31 March 1991

	1991 £M	1990 £M
INCOME	40.1	32.7
EXPENDITURE:		
Staff costs	55.1	48.8
Accommodation charges	7.0	8.9
Other costs:		
Operational activities — Observations, Central Forecasting, Data Collection and Processing	23.3	25.2
Commercial, Research and Administration	17.5	18.5
International Subscriptions	4.2	4.1
	107.1	105.5
NET EXPENDITURE	67.0	72.8

STATEMENT OF ASSETS AND LIABILITIES at 31 March 1991

	1991 £M	1990 £M
TANGIBLE FIXED ASSETS	68.5	63.0
CURRENT ASSETS:		
Stocks	2.3	2.1
Debtors	7.6	13.7
	9.9	15.8
CURRENT LIABILITIES:		
Creditors	1.9	1.7
NET CURRENT ASSETS	8.0	14.1
TOTAL ASSETS LESS LIABILITIES	76.5	77.1

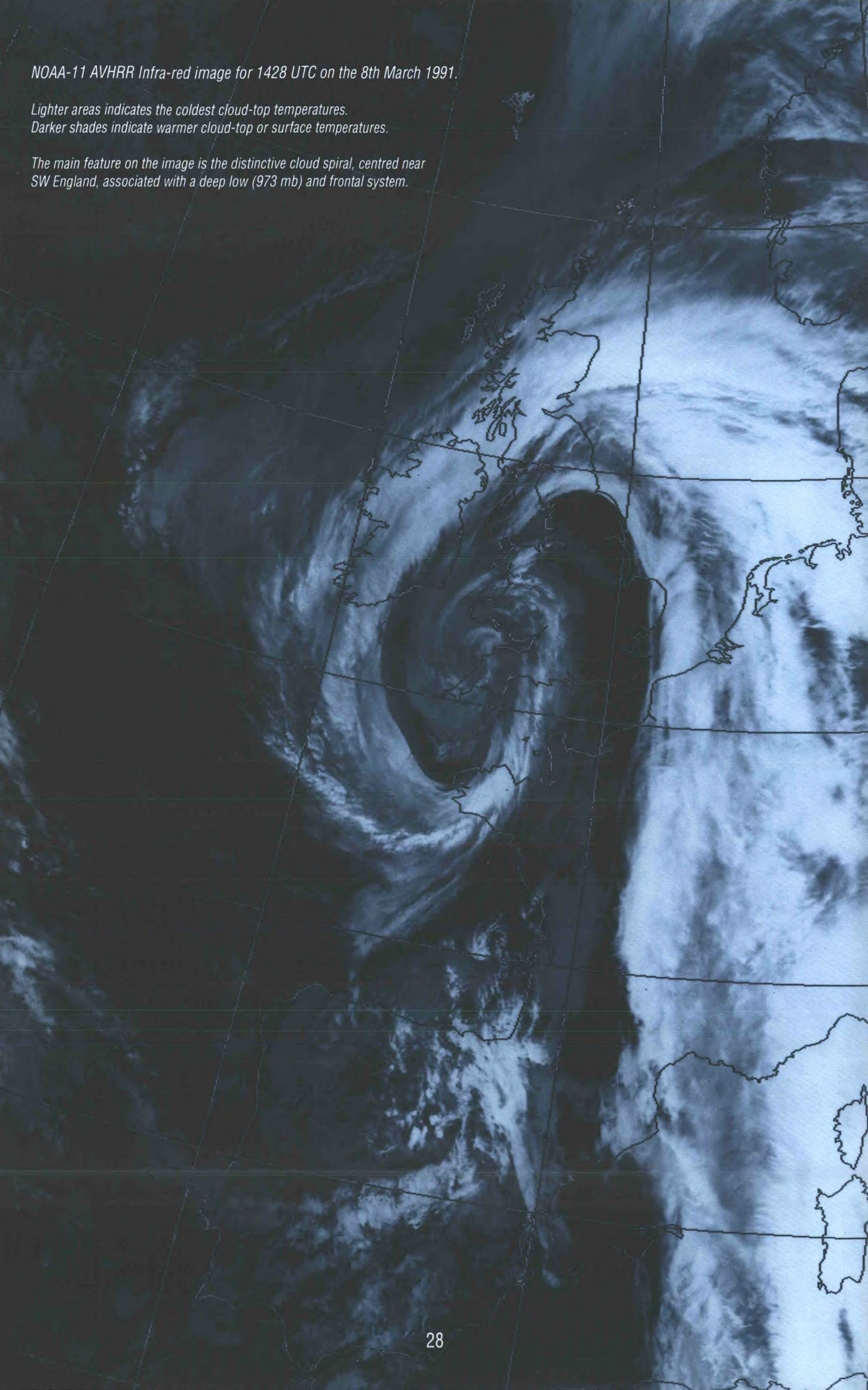
The Accounts were approved by the Chief Executive and the Directors of the Meteorological Office on 25 June 1991.

STAFF NUMBERS

The numbers of staff employed by the Office in Civil Service grade bands were as follows:

	At 31 March 1991	At 31 March 1990
Unified Grades 2–7	172	160
Other grades:		
Scientific	1800	1787
Technical	151	156
Administrative and support	324	298
Locally employed civilians overseas	43	46
Total	2490	2447

The information shown above is extracted from the Annual Report and Accounts for the year, a copy of which is available on request to: Corporate Communications, The Met. Office, Bracknell, Berks RG12 2SZ.



NOAA-11 AVHRR Infra-red image for 1428 UTC on the 8th March 1991.

Lighter areas indicates the coldest cloud-top temperatures.
Darker shades indicate warmer cloud-top or surface temperatures.

The main feature on the image is the distinctive cloud spiral, centred near SW England, associated with a deep low (973 mb) and frontal system.

Headquarters

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Tel. 0344 420242

Public Service Offices

Aberdeen Weather Centre	0224 211841
Belfast International Airport	08494 22804
Birmingham Weather Centre	021-717 0571
Bristol Weather Centre	0272 279272
Cardiff Weather Centre	0222 390420
Glasgow Weather Centre	041-248 7272
Kirkwall Airport, Orkney	0856 2421 ext 137
Leeds Weather Centre	0532 457753
London Weather Centre	071-430 5511
Manchester Weather Centre	061-477 1017
Newcastle Weather Centre	091-232 3808
Norwich Weather Centre	0603 630164
Nottingham Weather Centre	0602 384094
Plymouth Weather Centre	0752 251869
Southampton Weather Centre	0703 220646
Sella Ness, Shetland	0806 242069

For information concerning recruitment to the Meteorological Office, please contact:

Mrs Kimberley Turner
Recruitment Manager
Meteorological Office (PM)
London Road
BRACKNELL Berks RG12 2SZ

Acknowledgements

The Meteorological Office wishes to acknowledge the contributions made by the following in supplying photographic material:

Anglian Water plc, British Airways, European Space Agency, Eumetsat, Mercury Press Agency Ltd, National Rivers Authority, Pictor International —London, QA Photos Ltd, Tony Stone Photolibrary, University of Dundee.