Annual Report 2007

European Centre for Medium-Range Weather Forecasts

Contents

Foreword by the Director

2007 was a very active year with significant achievements for many aspects of ECMWF's activities. Two key activities were the operational use of the data delivered by the new European MetOp-A satellite and the procurement of the next supercomputer. The main achievements are that ECMWF not only continued to improve its forecasting system and maintained its lead, but also managed to provide successful early warnings for the main severe weather events that affected Europe.

In line with our long-term strategy, most of our activities are dedicated to improving our forecasting system, with particular focus on severe weather. ECMWF's forecast model (the IFS model) underwent important upgrades in its physical parametrizations during 2007. The main change in the first upgrade, implemented on 12 June 2007, was the introduction of a new radiation package for short-wave radiation and cloud-radiation interaction. The second upgrade, on 6 November 2007, introduced a major change to the convection scheme. These changes have considerably reduced the systematic errors of the Centre's model.

EUMETSAT's polar-orbiting MetOp-A satellite was launched on 19 October 2006. Data from two instruments on-board the satellite were incorporated into the ECMWF operational forecasting system on 11 January 2007 – less than three months after the launch. The most important new data, radiances from the IASI instrument, were used operationally from 12 June. This was just over 12 weeks after the first data were disseminated to numerical weather prediction (NWP) centres and only 8 months after the launch of the MetOp-A satellite. By that time it was already possible to demonstrate the positive impact of these new data on the quality of the weather forecasts.

Changes to our forecasting models and the availability of more observation data, especially from new meteorological satellites, contributed to the continuing improvement of our weather forecasting skills. As a result we maintained our position of world leader in global numerical weather prediction in 2007. Moreover, with the expected impact of climate change, correctly predicting severe weather events becomes more and more important for our Member States. In 2007, several major severe weather events in Europe (e.g. the extreme winds associated with storm Kyrill which affected Western Europe in

January, flooding in the UK in July and the storm surge in the North Sea in November) were forecast well in advance, thus allowing Member States to provide successful early warnings.

To carry on improving the quality of our forecasts needs us to continually upgrade our computing facilities. At its session in December the ECMWF Council accepted the Centre's proposal to select IBM for the provision of our next supercomputer and decided to further increase the funding from 2011. This marked the achievement of a long and challenging process. Installation of the supercomputer will take place in steps throughout 2008. The new High Performance Computing Facility will initially provide an increased performance by a factor of five (to 19 teraflops sustained), allowing for the resolution of the forecast model to be increased from 25 km to 16 km in 2009–2010. The performance will be further increased by a factor of 2 in 2011.

The distribution system also needed to be upgraded. The migration of the Regional Meteorological Data Communication Network (RMDCN) from Frame Relay architecture to Internet Protocol Virtual Private Network architecture was achieved on 18 June. This marked the successful end of a long process and was a major step forward in improving data communications between ECMWF Member and Co-operating States, as well as within the meteorological community as a whole.

'Changes to our forecasting models and the availability of more observation data, especially from new meteorological satellites, contributed to the continuing improvement of our weather forecasting skills. As a result we maintained our position of world leader in global numerical weather prediction in 2007.'

Further developing the Centre's support to the European Union has been an important element in ECMWF policy over recent years – this activity continued in 2007. Our main contribution is directed to the Global Monitoring for Environment and Security (GMES) initiative. In particular, ECMWF remained involved in the development of the atmospheric services component by contributing to and coordinating the GEMS project (which deals with global monitoring of atmospheric gases and aerosols and improved air quality forecasts). A proposal for a follow-up project (MACC) was prepared during 2007.

Through discussions with the Member States, the Centre's governance and financial management was reviewed. A plan was then set up to ensure that ECMWF will deliver best value for the Member States whilst maintaining its acknowledged leadership in NWP. It includes developing a long-term solution for the Centre's pensions' payments, considering changing accounting and auditing policies to new international standards, developing a scheme for activity-based costing, and conducting a technical, strategic and financial risk analysis.

With Montenegro and Slovakia (from 1 January 2008) signing co-operation agreements, the number of States supporting ECMWF increased to 30 in 2007. New States are expressing interest in developing co-operation with ECMWF. Also the process of accepting the amended Convention made good progress. The amended Convention will open the door for new States (or current Co-operating States) to join ECMWF as Members.

Reporting on the year 2007 could not but mention the shock of the death of Tony Hollingsworth. He was formerly Head of Research then co-ordinator of GEMS, but above all Tony was one of the main inspirational contributors to the development of ECMWF throughout his whole career. We will make sure that we continue to realize his dreams for the development of a full Earth-system forecast.

Dominique Marbouty
Director, ECMWF

Our mission

Principal objective

To maintain the current rapid rate of improvement of ECMWF's global, medium-range weather forecasting products, with particular emphasis on early warnings of severe weather.

Complementary objectives

- Improve the quality and scope of monthly and seasonal-to-interannual forecasts.
- Enhance support for Member States' national forecasting activities by providing suitable boundary conditions for limited-area models.
- Deliver real-time analyses and forecasts of the atmosphere's composition.
- Carry out climate monitoring through regular reanalyses of the Earth-system.
- Contribute towards the optimisation of the Global Observing System.

To achieve these objectives, ECMWF:

- Develops numerical methods for medium-range, monthly and seasonal weather forecasting.
- Prepares medium-range, monthly and seasonal weather forecasts for distribution to the National Meteorological Services of the Member States and Co-operating States.
- Conducts scientific and technical research directed at improvement of these forecasts.
- Collects and stores meteorological data.

Governance and financial management

ECMWF developed worldwide leadership in its scientific and technical areas of responsibility with a very lean administration and low overheads. Good management practices are considered essential for ensuring the continual delivery of best value for money to Member States.

The Centre is, therefore, committed to an ongoing process of reviewing and improving its management policies to ensure that it:

- Delivers best value for Member States.
- Monitors and further improves its high level of efficiency.
- Is well positioned to address future technological and scientific challenges in order to maintain its worldwide. acknowledged leadership position in Numerical Weather Prediction.

ECMWF – leading the world in weather forecasting

ECMWF has a worldwide reputation for providing the most accurate medium-range global weather forecasts. The National Meteorological Services of Member States and Co-operating States use ECMWF's products for their own national duties, in particular to give early warning of potentially damaging severe weather. Also researchers and scientists around the world use ECMWF's forecast products to monitor the environment and analyse climate change.

ECMWF uses a highly advanced computer modelling technique, called numerical weather prediction (NWP), to forecast the weather from its present measured state. Its complex calculations require a constant input of meteorological data, including air pressure, temperature, wind speed and direction, and humidity. This information is collected by satellites and other observing systems such as automatic and manned stations, aircraft, ships and weather balloons.

The data are fed into ECMWF's databases and assimilated into its advanced NWP models which produce:

- Medium-range forecasts, predicting the weather up to 15 days ahead.
- Monthly forecasts, predicting the weather on a weekly basis 30 days ahead.
- Seasonal forecasts up to 12 months ahead.

Over the past three decades ECMWF's activities and wide-ranging programmes of research and development have played a pioneering role in the remarkable advancement of weather forecasting and data assimilation systems. The Centre's strategy for 2006–2015 underlines its commitment to maintaining the current rapid rate of improvement of its global medium-range forecasts and products, with special focus on the early warning of severe weather.

Key events of the year

11 January
Assimilation of radiances from the Advanced Microwave Sounding Unit (AMSU-A) and from the Microwave Humidity Sounder (MHS) on-board EUMETSAT's polar orbiting MetOp-A satellite, launched on 19 October 2006, became operational.

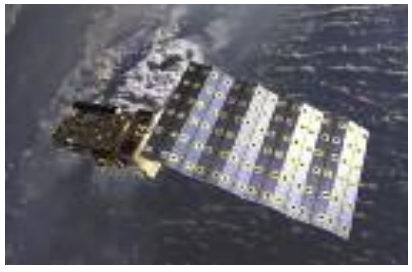
18 January
Based on ECMWF's medium-range forecasts of the severe winter storm Kyrill, which affected many areas in Europe, National Meteorological Services were able to issue early warnings to mitigate the impact of the storm. Using ECMWF forecasts the Deutscher Wetterdienst issued severe weather warnings for the whole of Germany for the first time.

24 January
A major upgrade of the web service hardware systems was completed resulting in a significant improvement in the response of the web pages.

7 March
After Morocco became the first non-European Co-operating State on 1 December 2006, Mr Abdelkébir Zahoud, Secretary of State to the Ministry of Territorial Development, Water and Environment in Charge of Water of the Kingdom of Morocco, visited ECMWF, together with Mr Mustapha Geanah, Director of the Moroccan National Weather Service.

15 March
Operational forecasts started using System 3, the new seasonal forecast system.

19 March



Assimilation of radiances from the High-resolution Infrared Radiation Sounder (HIRS) instrument on-board EUMETSAT's polar orbiting MetOp-A satellite, launched on 19 October 2006, became operational.

30 March
The invitation to tender for the Centre's new High Performance Computing Facility was issued, with the closing date for tenders set at 1 June, after which ECMWF evaluated the bids.

22 May
The TIGGE database of operational ensemble forecasts from various global forecasting centres became accessible to scientists in near real-time for research and educational purposes.

5 June
A new cycle of the ECMWF forecast and analysis system was implemented (Cycle 32r2). The changes produced a significant improvement in the forecasts of the tropical troposphere at all forecast ranges.

8 June
A new milestone was reached in the Centre's Regional Meteorological Data Communication Network (RMDCN) with the successful completion of the migration of the architecture from Frame Relay to a new Internet Protocol Virtual Private Network.

12 June
Radiance data from the Infrared Atmospheric Sounding Interferometer (IASI) and surface winds from the Advanced Scatterometer (ASCAT) on-board EUMETSAT's polar orbiting MetOp-A satellite, launched on 19 October 2006, were incorporated into the operational forecasting system.

19 June
The Monitoring Atmospheric Composition and Climate (MACC) project was proposed to the European Commission.

22 June

Mr Jörg Hennerkes, State Secretary of the German Federal Ministry of Transport, Building and Urban Affairs, visited ECMWF.

28 June

The inauguration of ECMWF's new office block at its Headquarters in Reading was celebrated.

31 August
The 10-day ozone forecast issued by ECMWF showed the stratospheric ozone depletion in early September with minimum total column ozone less than 150 Dobson Units.

1 November
The co-operation agreement between Slovakia and the Centre was signed. It entered into force on 1 January 2008.

5 November
Montenegro became a Co-operating State following the signature of the co-operation agreement by Mr Predrag Nenezic, Minister of Tourism and Environment of Montenegro, and the Director of ECMWF, Mr Dominique Marbouty.

6 November
A new cycle of the ECMWF forecast and analysis system was implemented (Cycle 32r3). This included significant changes to the model physics with a beneficial increase in model activity globally, particularly in the tropics.

7–9 November
A workshop was held at ECMWF to celebrate the fifteenth anniversary of operational medium-range ensemble prediction.

9 November
As a result of an early warning of a storm surge in the North Sea, the Royal Netherlands Meteorological Institute (KNMI) issued a severe weather warning. Consequently, the barrier protecting Rotterdam was closed for the first time.

20 December
The contract for the Centre's next High Performance Computing Facility was signed with IBM.

Predicting severe weather

Storm damage from the severe storm Kyrill. Photographs © picture-alliance/ dpa

The ECMWF strategy puts the early warning of severe weather as one of its principal goals. This is particularly important as severe weather is predicted to become more frequent and more intense in some parts of the world under climate change. ECMWF can contribute to the development of strategies for adapting to climate change. In particular, ECMWF's emphasis on the provision of reliable predictions of severe weather can be seen as a key contribution to help society adapt to the dangers and threats associated with global warming.

Benefits of warnings of severe weather

The increased time gained by issuing accurate warnings of severe weather can be crucial to save lives, for instance by evacuating a large number of people from endangered areas (e.g. storm surges in the North Sea), or for taking precautions to avoid major threats to goods and services (e.g. extreme winds).

Thanks to the delivery of medium-range forecasts twice daily by ECMWF, the Member States' National Meteorological Services can improve the protection of citizens' lives and property in Europe and beyond by providing effective early warnings of severe weather. In addition, ECMWF's Ensemble Prediction System (EPS) can deliver reliable and user-specific warnings of extreme weather in a probabilistic way.

ECMWF's Extreme Forecast Index (EFI) was developed as a tool to identify where the EPS forecast distribution differs substantially from that of the model climate. It is an integral measure referenced to the model climate so it contains all the information regarding variability of a weather parameter, such as temperature, in location and time. Thus users can recognise the abnormality of a weather situation without having to define specific space- and time-dependent thresholds.

ECMWF's monthly and seasonal forecasts provide early predictions of events such as heat waves, cold spells and droughts, as well as their impacts on sectors such as agriculture, energy and health. Since ECMWF runs a wave model, there are also predictions of coastal waves and storm surges in European waters which can be used to provide warnings.

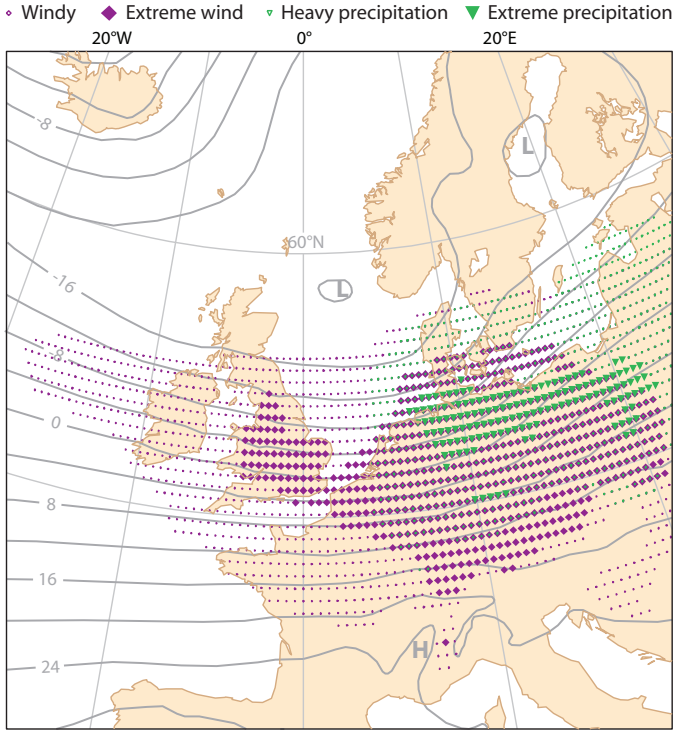
Some examples of good predictions of extreme weather

Severe storm over northern Europe

Storm Kyrill was associated with exceptionally strong winds which affected northern Europe, particularly the British Isles and northern Germany, on 18 January 2007. The storm resulted in some fatalities in Germany as well as considerable structural damage and disruption to transport.

The Centre's medium-range forecasts gave early warning of Kyrill, and indicated an increasing probability of extreme winds as the event approached. The Extreme Forecast Index from the EPS forecast from 15 January gave a strong signal for widespread extreme winds.

Based on the ECMWF forecasts the Deutscher Wetterdienst (DWD) was able to issue severe weather warnings for the whole of Germany. These allowed national and regional authorities to prepare for the storm and take precautionary measures.



***The Extreme Forecast Index (EFI) for storm Kyrill**. The symbols show areas where exceptionally strong winds and heavy rainfall are expected during 18 January 2007, based on the EPS forecast from 00 UTC on 15 January. Also shown are the contours of the 1000 hPa geopotential height from the ensemble mean for 12 UTC on 18 January.*

Severe storm "Kyrill" over Germany in January 2007

(Based on original from Deutscher Wetterdienst (DWD))

Kyrill claimed the lives of at least ten people in Germany. Numerous trees were uprooted, while roofs and parts of buildings were torn off. Berlin's main train station was completely evacuated. The storm caused considerable air-traffic disruption and all local and long-distance rail services were suspended for several hours throughout Germany.

NWP models, in particular ECMWF's operational model, provided generally good and above all early indications of the hurricane-force storm. As the storm approached, ECMWF continued to provide consistently good forecasts of the extreme weather.

Using the results of runs of the operational model up to 18 January 2007, the Deutscher Wetterdienst (DWD) issued severe weather warnings for the whole of Germany for the first time ever; they were characterised by good timeliness and consistency. Regional warnings of extreme weather were accurate not only for their respective regions, but also for the predicted extreme values.

The response from users of the DWD's warning system was positive in the wake of Kyrill. The DWD's early warnings enabled North Rhine-Westphalia's Interior Ministry to increase staffing levels in its crisis management centre, and the Federal Office for Civil Protection and Disaster Assistance to set up an emergency task force. Thanks to the Internet and close collaboration with the media, the DWD was also able to provide the general public with detailed information at an early stage.

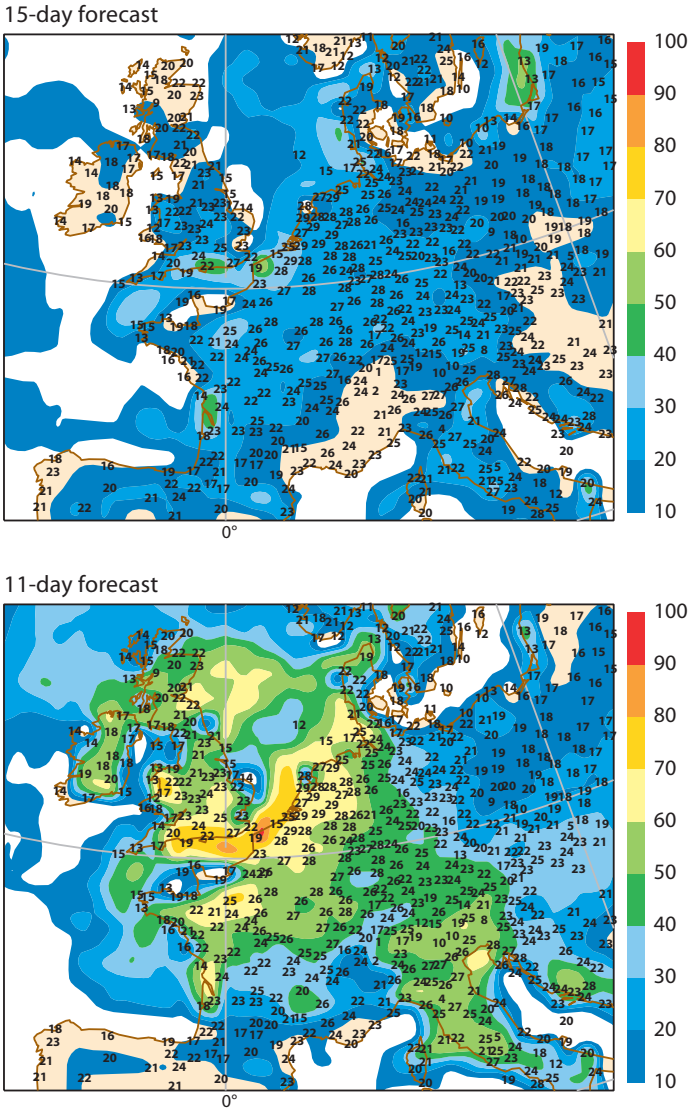
In a letter to the DWD's President, Wolfgang Kusch, the Federal Minister of Transport, Building and Urban Affairs, Wolfgang Tiefensee, acknowledged the DWD's contribution to protecting the public interest in Germany:

"(...) The DWD's early warnings engaged public interest and provided national and regional response teams with timely and appropriate information. High quality forecasts and accurate warnings enabled the public to prepare for the severe storm in good time and take suitable precautionary measures (...)".

High temperatures in April

Exceptionally high temperatures were recorded in several countries during April 2007. On 15 April, temperatures of 27 to 30°C occurred in the Netherlands, Belgium and regions of France, Germany and Italy. The Rotterdam marathon was abandoned due to concerns over the extreme heat.

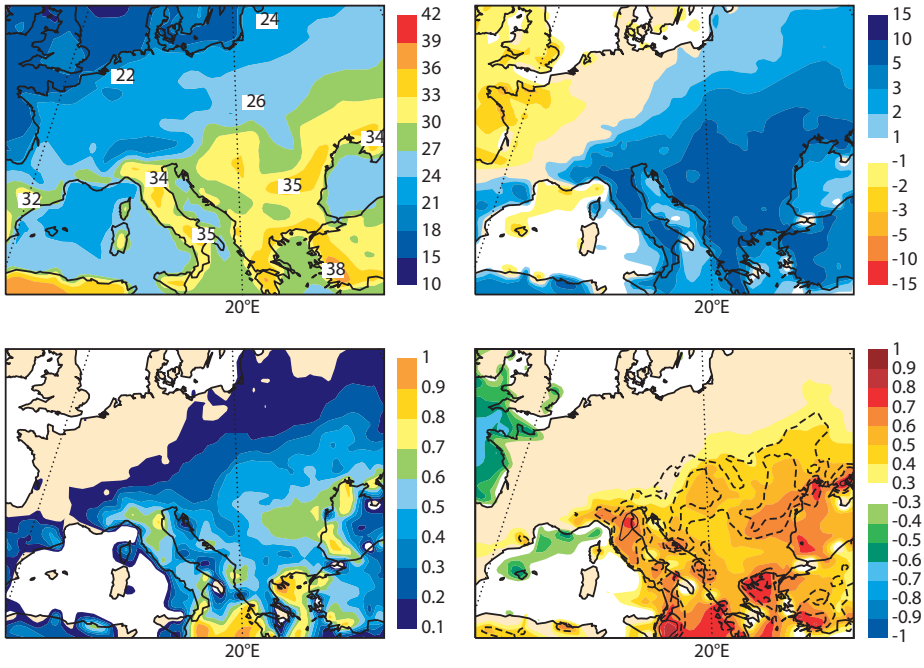
The 15-day and 11-day forecasts from the Variable Resolution EPS (VarEPS) for this event illustrate the potential of the system. Fifteen days in advance the VarEPS forecast already shows a substantially increased risk of high temperatures over a wide area for 15 April. The forecast made four days later shows probabilities of over 50% for exceptionally high temperatures in many places.



***Extended-range forecasts of exceptional high temperatures on 15 April 2007**. The numbers show the maximum observed temperatures on 15 April. The shading shows the EPS probability of the maximum temperature exceeding the 95th percentile of the climate distribution. The increased risk of high temperatures can be clearly seen in the 15-day forecast (top panel) and 11-day forecast (bottom panel).*

Heat wave in south-eastern Europe

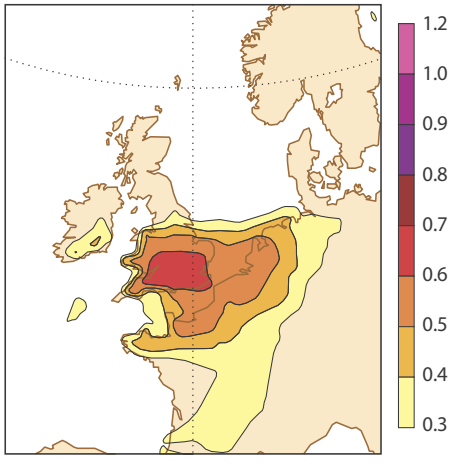
A heat wave affected south-eastern Europe for about one week, centred on 20 July 2007. Temperatures rose above 40°C. More than 500 casualties were reported in Hungary. A good early warning was given by the medium-range forecasting system, with an indication of high temperatures already being apparent in the 15-day forecasts. The set of 10-day forecast products from the EPS for 20 July gave a consistent signal.



EPS products predicting the heat wave in Central Europe during July 2007. *The strong heat wave affected the south-east of Europe for one week centred around 20 July. The products shown are based on the 15-day forecasts of two-metre temperature from the EPS: mean maximum temperature (top left), maximum temperature anomaly (top right), probability of the maximum temperature exceeding the 95th percentile of the climate distribution (bottom left) and the EFI for maximum temperature (bottom right). The EPS products gave a clear early warning of the heat wave.*

Flooding in England and Wales

June and July 2007 were record wet months in England and Wales, with periods of intense precipitation resulting in severe flooding in many areas. The exceptional rainfall over the two-month period was well forecast, as indicated by the Extreme Forecast Index.



Extreme Forecast Index (EFI) indicating heavy rainfall over southern UK on 20 July 2007. *The EFI gives a good indication of an area of exceptional precipitation in the 72-hour forecast. The higher values indicate more extreme events.*

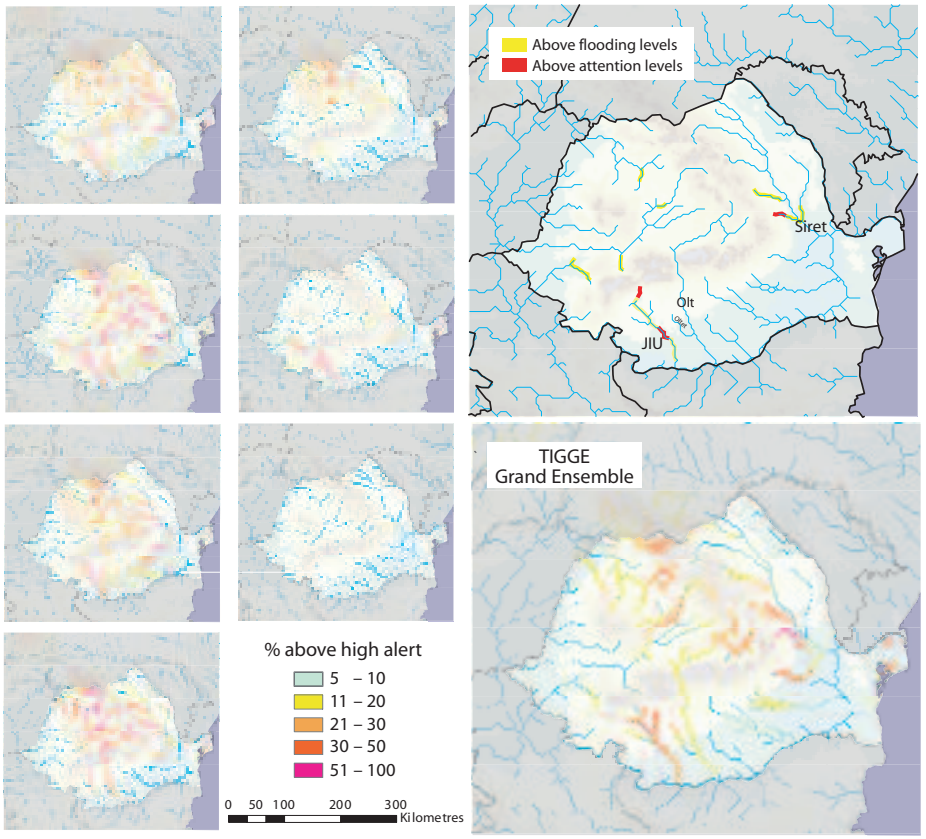
Flood warnings using ensemble hydrological predictions

The potential of using ensembles for early flood warning has been investigated. Use was made of the TIGGE archive – a database of ensemble forecasts from various global forecasting centres. The investigations focused on the first major flooding event since the TIGGE archive became operational: the October 2007 floods on several tributaries to the Danube in Romania (Siret, Jiu, Olt and Arges).

216 ensemble forecasts have been used to form a TIGGE grand-ensemble forecast by merging the individual forecasts from seven centres with equal weights (more complex methods of merging forecasts are unjustified as floods only happen infrequently).

River flow simulations were generated using a version of the European Flood Alert System (EFAS, developed by the EU's Joint Research Centre). The EFAS was driven by weather forecasts either from single ensembles or from the TIGGE grand-global ensemble. The thresholds of the river discharge were given by the warning thresholds of the EFAS, therefore they are directly related to the risk of flooding. Observed river discharge is derived by routeing observed rainfall through the hydrological model as no spatially distributed data are available.

This work is performed as part of the PREVIEW project and is one of several ways we assess the benefits of multi-model systems.



***Percentage of ensemble members exceeding the high alert threshold of river discharge**. Results are given for individual sets of ensemble forecasts from seven centres (small panel) and the TIGGE grand-ensemble (bottom-right panel) issued at 12 UTC of 19 October valid for 24 October 2007. River flows generated by observed precipitation are used as reference (top-right panel). The ensemble forecasts are from ECMWF, UK Met Office (UKMO), National Centers for Environmental Prediction (NCEP), Meteorological Service of Canada (MSC), Japanese Meteorological Administration (JMA), Chinese Meteorological Administration (CMA) and Bureau of Meteorology (BOM).*

Support for severe weather event forecasting

ECMWF plays a vital role in supporting the international community by providing specific forecasts of severe weather on request. Such support is used mainly for humanitarian relief, disaster prevention and post-crisis reconstruction.

Requests for forecast guidance are channelled via the WMO Secretariat. Sometimes requests originate from UNOSAT – this is a United Nations programme created to provide the international community and developing countries with enhanced access to satellite imagery and Geographic Information System services.

In the second half of February tropical cyclones affected south-east Africa, in particular the coastal regions of Mozambique where widespread flooding had occurred earlier in the month. The strong winds caused additional hazards in the region. ECMWF received a request from UNOSAT for additional forecast guidance to be made available to the regional authorities. There was a prompt response and ECMWF provided, for a limited period, additional forecast products on the web. This quick response was acknowledged with appreciation.

Similarly, in May, ECMWF made forecasts available to the Maldives after a serious storm surge affected 65 islands. These forecasts were used to support the emergency relief operations.

Importance of ECMWF weather forecasts for the Brahmaputra flood forecasts in 2007

(Based on original from University Corporation for Atmospheric Research (UCAR))

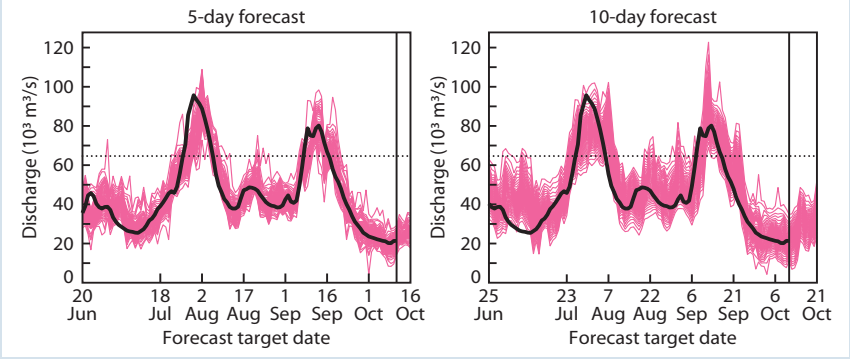
The Climate Forecasting Application to Bangladesh (CFAB) project has worked in partnership with ECMWF and the Asian Disaster Preparedness Center (ADPC). CFAB was able to provide warnings up to ten days in advance to the citizens of Bangladesh during two severe Brahmaputra flooding events that occurred in July–August and September 2007.

A pilot programme was established in five regions of Bangladesh in 2006 to warn citizens of future severe floods. This pilot was activated during the severe 2007 floods, providing advanced warning to approximately 110,000 Bangladeshi citizens. Warnings at such advanced lead times had a vital impact on Bangladeshi citizens' ability to protect livestock, fisheries, water and food supplies, and to evacuate areas under threat.

ECMWF provides data and weather forecasts, which are fed into hydrological models of the Ganges and Brahmaputra river basins. The system also incorporates estimates of precipitation from two satellite-based systems developed at the NASA Goddard Space Flight Center and NOAA Climate Prediction Center, along with discharge measurements of rivers in Bangladesh from the Flood Forecasting and Warning Centre. The forecasting system uses modelling, weather forecasts and satellite data to compensate for a lack of river gauge data upstream of Bangladesh.

Forecasts of river flow beyond a five-day horizon rely on weather forecasts with a lead time of one to five days for the majority of the stream flow, with even greater reliance for longer lead times out to ten days. The CFAB forecasts exhibited useful skill out to ten days, with the skilful ensemble weather forecasts from ECMWF playing an essential role.

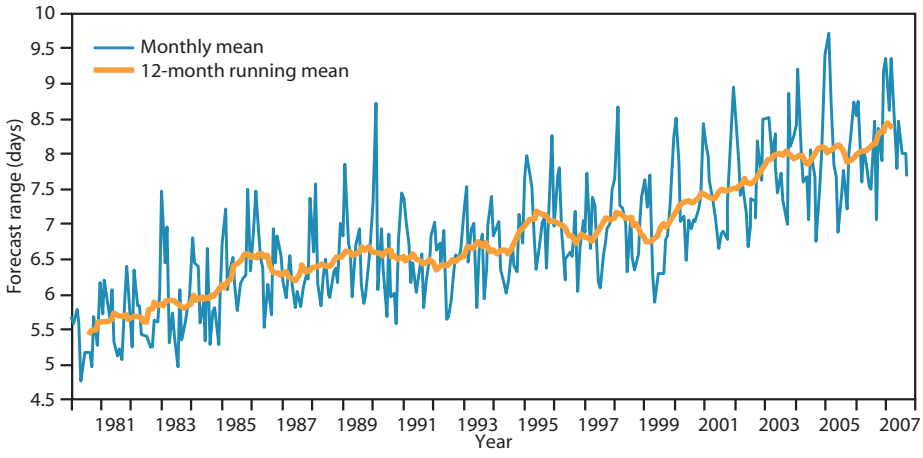
As can be seen from the figure, the observed water levels (black line) dropped slightly from 22 to 23 July, but exceeded the critical flood level four days later on 27 July and crested seven days later on 30 July. Similarly, from 2 to 4 September the water levels dropped, but breached the critical flood stage level four days later on 8 September and crested nine days later on 13 September. The CFAB forecasts were able to provide consistent warnings of both flooding events.



The medium-range Brahmaputra discharge forecasts. *Summary of the 5-day and 10-day Brahmaputra forecasts for the entire summer of 2007 plotted against the forecast target data. The magenta lines represent the 51 ensemble members. The bold black line indicates the observed values of discharge measured at Bahadurabad (from P.J. Webster Earth and Atmospheric Sciences, Georgia Institute of Technology, and T.M. Hopson, National Center for Atmospheric Research, Boulder, Colorado, USA).*

Evolution of the forecasting system

ECMWF is renowned worldwide for providing the most accurate medium-range global weather forecasts. It also provides forecasts to one and six months ahead. The wide-ranging programme of research at ECMWF continues to play a pivotal role in the remarkable advancement of weather forecast skill and the use of the rapidly developing satellite and in-situ observations of the atmosphere.



***Performance of the deterministic forecasting system**. The results show the monthly mean and 12-month running mean of the forecast range at which the anomaly correlation for 500 hPa operational forecasts drops to 60% for the extra-tropical northern hemisphere. This score shows a strong positive trend over the last two years.*

Performance of the operational forecasting system

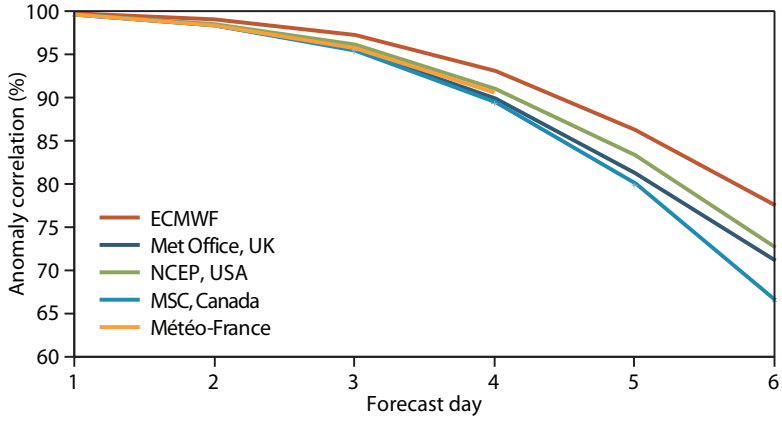
At ECMWF the performance of the forecasting system is assessed using a comprehensive verification system. Forecasts are verified against analyses and observations. The information is of value to users of the forecasts as well as scientists involved in improving the forecasting system. Some of the verification statistics are exchanged with other NWP centres on a regular basis.

There have been highly skilful forecasts of severe weather events such as extreme winds, flooding and storm surges.

The performance of the operational deterministic forecasting system was consistently good over the year. One notable reason for the overall high score is a continuing reduction in the number of poor individual forecasts.

The probabilistic forecasts generated by the Ensemble Prediction System (EPS) performed well throughout 2007. These forecasts have benefited substantially from the increase in model resolution that was implemented in 2006.

It is pleasing that the summer scores for forecasts of specific weather parameters, including precipitation, were the best ever produced by ECMWF.



***Comparison of the performance of various global forecasting centres during 2007**. The results show the anomaly correlation coefficient for the operational forecasts of 500 hPa height for Europe from five global forecasting centres. ECMWF maintained its lead over other global forecasting centres.*

During 2007, ECMWF maintained its lead over other global forecasting centres.

The ocean wave model continues to perform well. The quality of the forecasts is assessed against buoy data as part of an international inter-comparison project. This shows that the ECMWF wave model has a clear lead over other centres.

Upgrades to the forecasting system in 2007

ECMWF's forecast model, which forms part of the Integrated Forecast System (IFS), has been undergoing important upgrades in its physical parametrizations during the past two years, and more are on the way.

Such extensive and rapid changes in the model physics have not taken place for many years. Due to these various upgrades, the systematic errors of the IFS model have been considerably reduced. This is of benefit not only for the medium-range forecasts but also for the assimilation of observations. In addition, there is enhanced ability to represent the Earth's climate in long integrations coupled with ocean, sea-ice and land surface models. In fact the IFS model is getting much closer to being a true "Earth System Model".

Cycle 31r1

Cycle 31r1, introduced on 12 September 2006, contained a set of revisions to the cloud scheme, namely supersaturation with respect to ice and a more accurate discretization and fall speed for ice particles. Another major change was the replacement of the old and rather artificial "orographic roughness length" by a modern orographic form drag.

Cycle 32r2

With Cycle 32r2, introduced on 12 June 2007, further revisions to the orographic drag were made, and the representation of ice particles was further improved. However, the main change in this cycle was the replacement of the short-wave radiation scheme by the Rapid Radiative Transfer Model, developed by AER, Inc. This new model has 14 spectral intervals, and supports an advanced representation of cloud-radiation interactions called McICA (Monte-Carlo Independent Column Approximation). This provides an elegant solution to the long-lasting problem of optimizing the cloud superposition in model columns.

The greatest impact of the changes is in the tropical troposphere, which showed significant improvements at all forecast ranges. The radiation package modifies the balance between the short-wave heating and long-wave cooling by clouds, with a positive impact on the large-scale location of convection in the tropics. There are related improvements to the radiative fluxes at the top of the atmosphere. There are also moderate but statistically significant improvements in the extra-tropical troposphere, particularly in the first four days.

The EPS was tested for December 2006. In the extra-tropics, ensemble spread is similar to the operational suite, while at 500 hPa the ensemble-mean error is reduced. In the tropics the spread at 850 hPa is increased, moving closer to the ensemble-mean error.

Cycle 32r3

On 6 November 2007 a major change of the convection scheme was introduced (Cycle 32r3). The use of the "large-scale moisture convergence" was discontinued, and the scheme now uses only the properties of the convective updraft. This brings the IFS model in line with recent theories of convection. In addition, the soil hydrology was completely revised and geographical variations in soil texture were introduced for the first time in the IFS. The changes resulted in a more realistic representation of the soil moisture reservoirs. The vertical diffusion above the boundary layer was also improved and this produced a better simulation of stratocumulus clouds.

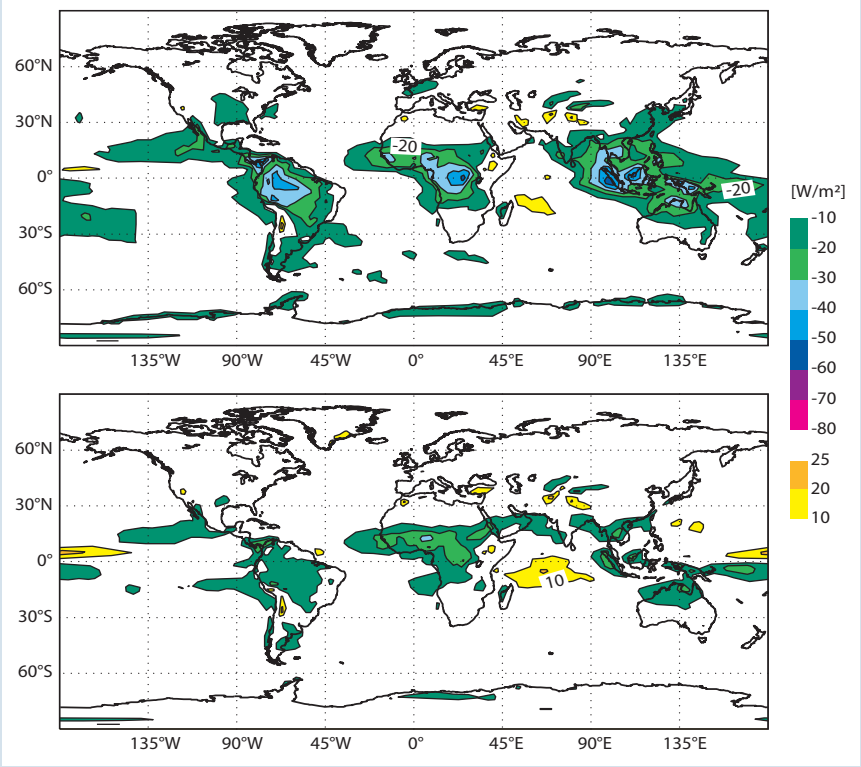
The impact of the new cycle on the performance of the forecasting system was tested in research mode for January to May 2007, and in pre-operational runs from June to September 2007. The new cycle showed improved scores for the extra-tropical southern hemisphere throughout the forecast range and for the northern hemisphere in the first half of the forecast.

The changes produced a substantial improvement to the lower tropospheric winds in the tropics compared to observations. Surface weather parameters have also improved in the new system, in particular through a reduction in the biases of two-metre temperature (mainly over the Americas) and better precipitation forecasts over Europe.

Introduction of Cycle 32r2

This version includes the following changes:

- Three-minimization version of 4D-Var assimilation scheme (T95/T159/T255) with improved moist linear physics (cloud and convection)
- Improved parametrization of the heterogeneous ozone chemistry
- New short-wave radiation scheme (RRTM-SW), plus McICA cloud-radiation interaction and MODIS albedo
- Retuned ice particle size
- Fine-tuned subgrid-orography scheme
- Use of convection in the tangent linear model for the calculation of tropical singular vectors
- Introduction of software for the monitoring of ASCAT and IASI data.



Impact of the new radiation package on the outgoing long-wave radiation. *The introduction of the new radiation package in Cy32r2 had a major impact on the climate of the model. The distribution of precipitation in the tropics was improved, with more precipitation over tropical land and in the Western Pacific. This is also reflected in the outgoing long-wave radiation (OLR) at the top of the atmosphere, which shows much smaller biases compared to observations by Clouds and the Earth's Radiant Energy System (CERES). The top panel shows the annual mean OLR difference between model and CERES with Cy32r1. The new cycle, Cy32r2, has been used for the bottom panel.*

The Ensemble Prediction System

Forecasts from NWP models depend sensitively on the initial conditions. Also the models cannot fully represent all the complex atmospheric processes. ECMWF's Ensemble Prediction System (EPS) aims at quantifying the uncertainty in the forecasts.

The EPS provides forecasters with a range of possible future scenarios which can be used to estimate the probability of specific weather events occurring during the forecast period. It has been a key element of the Centre's operational forecasting system since 1992, and has been upgraded several times.

Verification is an essential component of model development, and the use of a wide range of probabilistic verification tools is imperative when developing probabilistic forecast systems. Thus, the aim of the EPS verification scheme is to enable forecast performance to be assessed comprehensively, quickly and reliably.

The introduction of the Variable Resolution EPS (VarEPS) allowed the EPS to be extended daily to 15 days, with the running of the last five days at lower resolution. VarEPS will also let the monthly forecast system be produced as an extension of the EPS, thus developing a unified approach to medium- and extended- range predictions at ECMWF. Such unification will allow the reforecast dataset, necessary to allow the monthly forecasts to be corrected for systematic model error, to be applied to calibrate the medium-range EPS.

Use of satellite observations

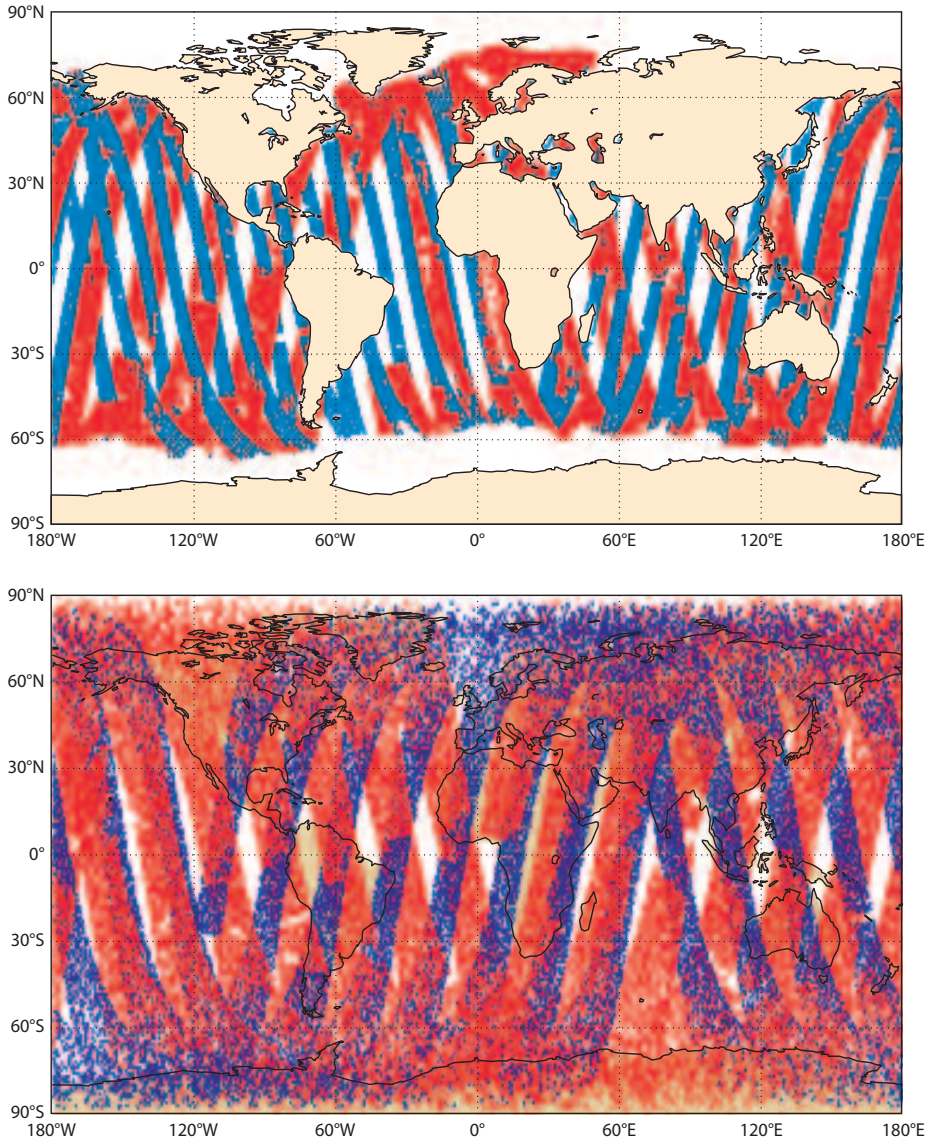
The increasing amount of satellite data and the development of more advanced ways of extracting information from that data have made a major contribution to improving the accuracy and utility of NWP forecasts.

ECMWF continuously endeavours to improve the use of satellite observations for NWP. Following the successful launch of EUMETSAT's polar-orbiting MetOp-A satellite on 19 October 2006, extensive efforts were dedicated to starting the assimilation of the data from its various instruments. No less than eight instruments on-board MetOp-A are of direct relevance to global NWP, with the Infrared Atmospheric Sounding Interferometer (IASI) being the most promising in terms of its potential impact on forecasts. IASI measures infrared radiation from the Earth's atmosphere with an unprecedented spectral resolution. This allows detailed atmospheric structures of temperature and composition to be determined more accurately than has previously been possible with any other operational satellite instrument.

Radiances from the AMSU-A, MHS and HIRS instruments on-board MetOp-A were made available to the users very shortly after launch. The radiances were immediately monitored operationally. An initial analysis of the monitoring statistics revealed that the noise characteristics of the three instruments were well within specifications and comparable to similar instruments on-board NOAA satellites. Following successful impact trials, the operational assimilation of data from AMSU-A and MHS started on 11 January 2007, shortly followed by HIRS on 19 March.

Radiances from IASI were incorporated into the operational forecasting system on 12 June 2007 – just over 12 weeks after the first data were disseminated to NWP centres and only 8 months after the launch of the MetOp-A satellite. This could only be achieved due to the recent experience gained from ECMWF's extensive use of a similar sounder on a National Aeronautics and Space Administration (NASA) spacecraft. The use of the IASI data has led to significantly improved weather forecasts.

ASCAT (Advanced Scatterometer), also on-board the MetOp-A platform, provides estimates of surface vector winds over the oceans. The winds have been monitored at ECMWF since the start of dissemination on 31 January 2007 and a high-quality, stable wind product is obtained. The precision of the wind direction is excellent. Assimilation experiments with ASCAT surface vector winds showed a positive impact on forecast skill over the southern hemisphere. As with IASI, surface winds from ASCAT were included in the ECMWF operational forecast system on 12 June 2007.



***Satellite measurements of surface winds and radiances on 12 June 2007**. On this date the data from the ASCAT and IASI instruments on MetOp-A were assimilated operationally at ECMWF for the first time. The top panel shows surface winds from the QuikScat (blue) and ASCAT (red) scattterometers, and the bottom panel shows the radiances from IASI (purple) and AIRS (red) sounders.*

Improved ozone forecasts

It is important that models have a good representation of the processes affecting ozone, as well as other reactive gases. Ozone has an important role in the radiation balance of the stratosphere and is crucial for providing warnings about exposure to high levels of ultraviolet radiation.

Close collaboration between ECMWF, Météo-France and the European Centre for Research and Advanced Training in Scientific Computation (CERFACS) in Toulouse has led to an improved stratospheric ozone representation, in particular with the recent inclusion of heterogeneous chemistry effects in the IFS. These developments, together with the increased usage of observational data, have enabled ECMWF to predict ozone changes with increasing accuracy.

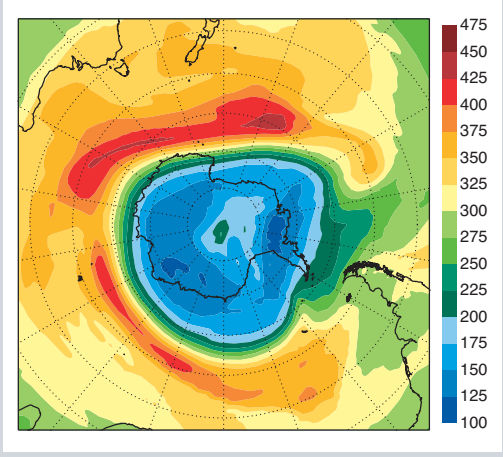
ECMWF's ozone forecasting is being developed further in collaboration with many institutes under the European project GEMS, which is part of the sixth EU Framework Programme for Research. GEMS is providing, in particular, a much improved representation of tropospheric ozone and other reactive gases. This work paves the way towards a fully operational monitoring and forecasting service to be developed as part of the Global Monitoring for Environment and Security (GMES) initiative under the auspices of the EU and ESA.

The ozone hole over Antarctica

With the beginning of the Antarctic spring and the return of the radiation, the chemical processes leading to the depletion of the Antarctic stratospheric ozone were initiated and produced what is commonly known as the 'ozone hole'. The 10-day ozone forecast issued by ECMWF on 31 August 2007 clearly showed the stratospheric ozone depletion in early September with minimum total column ozone amounts below 150 Dobson Units. This development indicated that a rather deep ozone hole was expected for 2007.

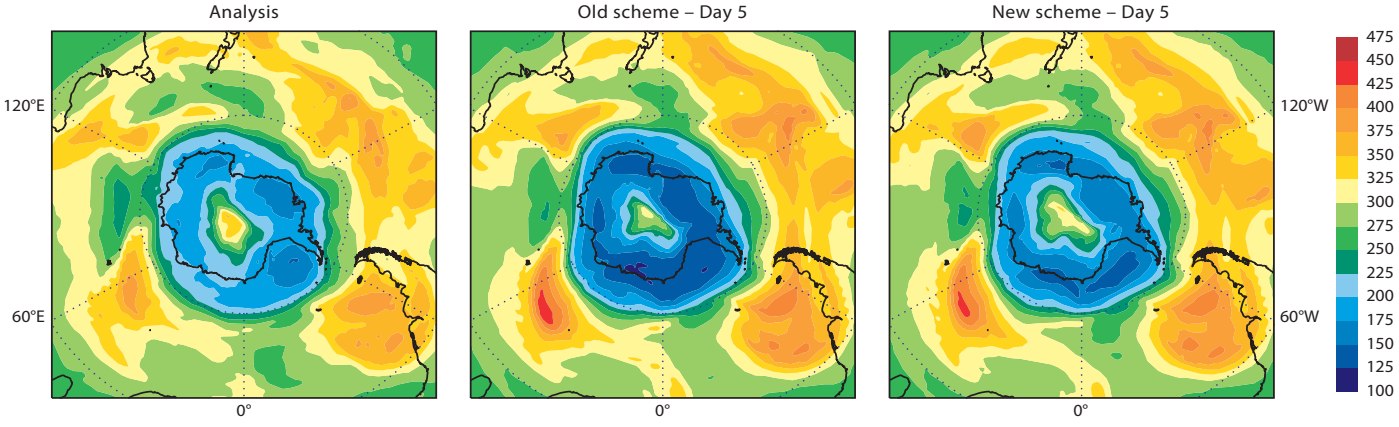
Very low temperatures were observed in July and August 2007 inside the southern polar vortex, supporting the generation of polar stratospheric clouds. These clouds are known to be catalysts in the heterogeneous chemical processes that lead to the strong reduction of ozone at the beginning of the Antarctic spring. The ozone hole usually reaches its deepest in October. The polar stratospheric vortex forms in wintertime and greatly reduces the inflow of warmer air masses from lower latitudes for several months each year.

The ozone analyses issued by ECMWF for July and August agree very well with satellite observations from the Ozone Monitoring Instrument (OMI) on-board the Earth Observing Systems' (EOS) Aura satellite. ECMWF has been producing ozone analyses since 1999. The ozone chemistry module, first developed at Météo-France, has been significantly improved since then through co-operation efforts, and incorporates an increasing number of observations from European satellites, namely ENVISAT (European Space Agency) and MetOp (EUMETSAT), as well as US satellites.



***ECMWF 10-day forecast of total column ozone (Dobson Units) over Antarctica**. The forecast is valid for 00 UTC on Monday 10 September 2007.*

***Improved modelling of total column ozone in Cycle 32r2**. From left to right, analysis, 5-day forecast with the old scheme and 5-day forecast with the new scheme (Cy32r2) of total column ozone (Dobson Units) during the onset of Austral spring. With the new scheme the forecast ozone hole over Antarctica is now less deep and is in much better agreement with the verifying analysis.*



Seasonal forecasting

Seasonal forecasts can be of great benefit to decision makers in a variety of economic sectors, particularly for the management of agricultural production and water resources.

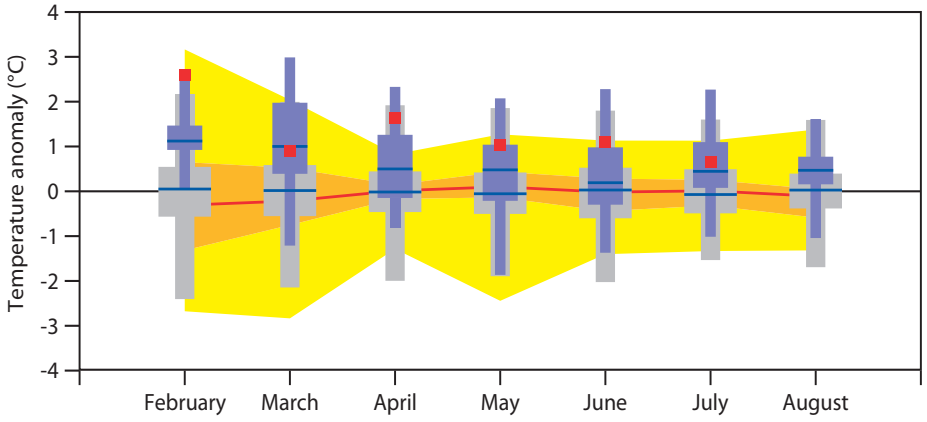
ECMWF has been running a seasonal forecast system since 1997. During this time, there have been only two versions, System 1 and System 2. A system consists of the following.

- Atmospheric and oceanic components of the coupled model.
- Data assimilation software to create initial conditions for the ocean.
- Coupling interface linking the two components.
- Strategy for ensemble generation and the reforecasts used for calibration (correction of the systematic errors).

A new seasonal forecasting system (System 3) became operational in March 2007. The set of products provided on the ECMWF website was improved and expanded. In particular, the range of "climagrams" has been increased, including area-averages for two-metre temperature and precipitation for 25 areas, extra-tropical teleconnection indices and rainfall-based monsoon indices.

Work continued on the implementation of a new ocean model for ECMWF activities associated with ocean analysis and coupled long-range forecasts. During 2007, efforts were concentrated on developing the first prototype of the coupled atmosphere-ocean system and on the initial development of a variational data assimilation system for the new ocean model.

ECMWF is actively engaged in the development of a multi-model seasonal forecast system known as EUROSIP (European Seasonal to Interannual Prediction system). As well as the ECMWF model, EUROSIP comprises the Météo-France and UK Met Office coupled forecast models. It is expected that the EUROSIP system will expand to include other models in the coming years. The science underpinning the multi-model concept is being developed within the ENSEMBLES project (see page 32).



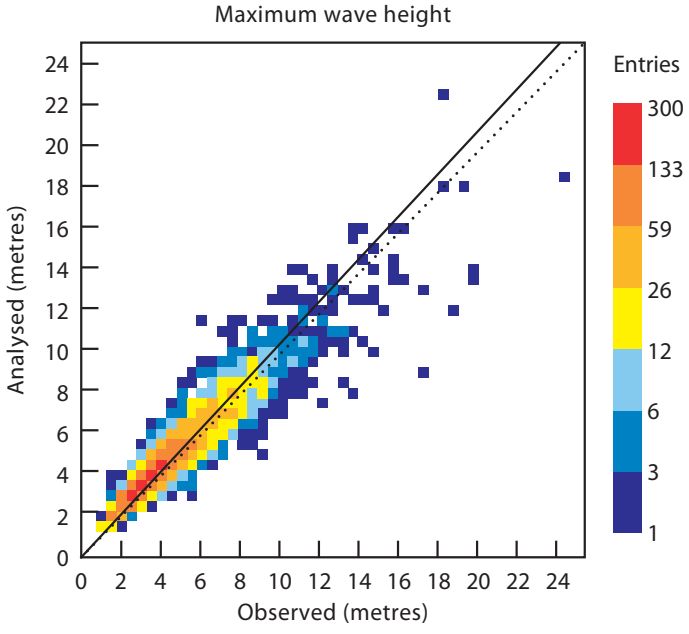
***Climagram of two-metre temperature anomaly over southern Europe from System 3 for the forecast started in February 2007**. The distribution of the monthly-mean temperature from the forecast is summarised in the purple box-and-whiskers. This can be compared to the model climate distribution (grey) and the analysis distribution from ERA-40 (shading). For each distribution the 5th, 33rd, 50th, 67th and 95th percentiles of the distribution are indicated. The red squares show the verifying analysis for March–July 2007. The warm conditions throughout the spring and summer were consistently indicated in the forecast.*

Ocean wave forecasting

The state of the sea is an important component of marine weather forecasts, and is critical for shipping, fisheries, offshore operations and coastal protection.

ECMWF's ocean wave forecasting model is coupled with the atmospheric model. As well as being part of the medium-range forecasting system, the wave model is also a key component of the Ensemble Prediction System (EPS), and the monthly and seasonal forecasting systems. Efforts have continued to provide better wave forecasts through enhancements to the wave model, use of new observations and improved assimilation of wave data.

The shallow water physics and numerical aspects of the wave model have been modified and extended. The new elements were bottom-induced wave breaking and an improvement to the representation of the non-linear transfer in shallow water. In addition, two simple alternative advection schemes were tested.



***Comparison of analysed ECMWF maximum wave height with buoy observations**. The validation indicates the high quality of the maximum wave height product.*

The monitoring of wind and wave satellite products from ERS-2, ENVISAT, Jason and QuikScat has continued. In addition the monitoring of ASCAT wind data started at the beginning of 2007.

During 2007 there was considerable improvement in the quality of the analysed surface winds because of the introduction of ASCAT wind vector data. The analysed wind speeds were validated against independent altimeter wind speeds. It was immediately evident that the assimilation of the ASCAT wind data resulted in the analysed wind speed error dropping by some 15%, particularly over the tropical oceans.

Four years ago a theory for the prediction of extreme events, such as freak waves, was developed at ECMWF. In the last year there have been further developments of the freak-wave warning system. The estimation of extreme events was made more realistic by the introduction of directional effects. In addition, two new wave parameters were developed which characterise extreme events, namely maximum wave height and the corresponding period. Validation against buoy observations shows that the maximum wave height product is of high quality.

Computing

Running ECMWF's complex weather forecast models in relatively short timescales requires supremely powerful computers and instant access to massive amounts of data. Central to the Centre's activities are its supercomputers and its unique archive of meteorological data, collected over three decades and stored in the Data Handling System.

Procurement of a new HPCF

The ECMWF Strategy 2006 to 2015 defines the principal goal for the coming years as maintaining the current, rapid rate of improvement of its global, medium-range weather forecasting products, with particular emphasis on improving early warnings of severe weather. The strategy includes specific targets for improvements in forecast skill and emphasises that the rate of increase in the performance of the High Performance Computing Facility (HPCF) is an essential factor for achieving these targets. It calls for a sustained performance of 20 teraflops from early 2009, with a gradual increase to between 150 and 200 teraflops sustained by 2015. The strategic requirements equate to an improvement over the existing HPCF system by a factor of 5 from 2009 and a factor of 10 to 12.5 from 2011.

At its 66th session (December 2006), the Council approved ECMWF's proposal to procure a replacement for the current HPCF. This would satisfy the computational needs for the period 2009 to 2013 and thereby enable the Centre to meet its strategic targets. During the following months, major efforts were dedicated to specifying the requirements for the new system. At the end of the procurement process the ECMWF Council authorised the Centre to enter into a service contract with IBM United Kingdom Ltd to replace the HPCF.

IBM will provide a system (Phase 1) based on POWER6 processors for the period 2009–2010. This system will consist of two identical compute clusters, each comprising about 250 32-cpu shared memory nodes, as well as two I/O (input/output) storage clusters managing 1.8 petabytes of disk storage in total. The two compute clusters, with about 8,000 processor cores, will have a total peak performance of about 290 teraflops and will deliver a total sustained performance of 19 teraflops on ECMWF's Integrated Forecast System (IFS). Thus, the new system will be about five times more powerful than the current HPCF.

The Phase 1 system will be replaced in its entirety in 2011 by Phase 2. As with Phase 1 this comprises two identical compute clusters, this time based on the POWER7 processor, and two I/O storage clusters managing over 2.5 petabytes of disk space. Phase 2 will double the total sustained performance of the IFS to more than 40 teraflops, and provide a service until mid-2013.

HPCF procurement process

- The Subgroup of the Technical Advisory Committee on the HPCF procurement met on 26–27 March to review the draft procurement documents in detail and discussed the evaluation procedures.
- The invitation to tender was issued on 30 March, with the closing date for tenders set at 1 June, after which ECMWF evaluated in detail the bids that were tendered.
- The Subgroup met again on 20–21 November to review the outcome and, in addition, an extraordinary session of the Technical Advisory Committee was held on 26 November, to review the report of the Subgroup.
- At its 68th session on 10–11 December, the ECMWF Council authorised the Director to enter into a service contract with IBM United Kingdom Ltd to replace the HPCF at the Centre from 2009 onwards.
- The contract was signed on 20 December 2007.

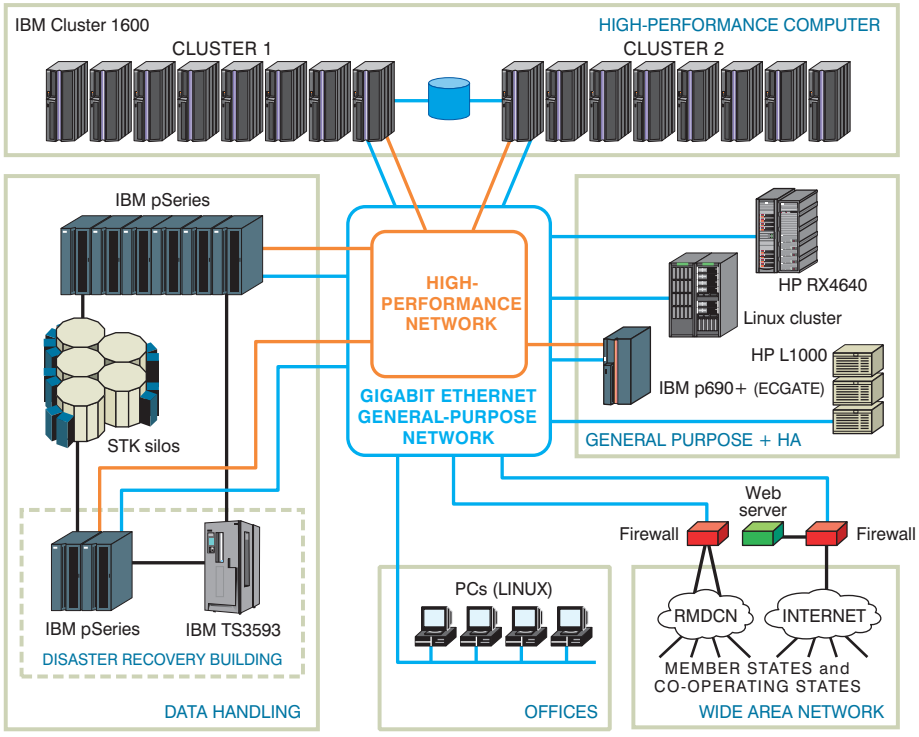
Use of the HPCF by ECMWF and Member States

The powerful High Performance Computing Facility (HPCF) is at the core of ECMWF's operational and research activities. The HPCF enables ECMWF to:

- Collect and check observations and assimilate these observations into the NWP models.
- Produce global medium-range, monthly and seasonal forecasts.
- Perform experiments to advance NWP techniques and products.
- Provide Member States with an invaluable resource for their research and development activities.

50% of ECMWF's high performance computer resources are allocated to research, 25% to producing forecasts and 25% to the activities of the Member States.

Significant efforts have been expended on providing a steadily increasing number of users from Member States and Co-operating States with support and advice about the use of ECMWF's computer facilities.



The current ECMWF computer configuration. *The computer and ancillary facilities are regularly updated to accommodate the greater computational power required by ECMWF and its Member States.*

Data Handling System (DHS)

Weather forecasting makes use of, and generates, very large volumes of data – observations, analyses and research experiments – that need to be stored for long periods. The data represent a valuable asset and incomparable archive of world-wide meteorological information from the past 30 years. They are used by researchers in meteorological and environmental studies, and are also available for educational and commercial purposes.

For many years ECMWF has operated a dedicated Data Handling System (DHS) in which all ECMWF users can store and retrieve data needed to perform a wide variety of research and development activities. The ease with which data in the DHS can be accessed is regularly commented upon by visiting scientists and other users of the system.

IBM's High Performance Storage System (HPSS) is the underlying data management system in which all of the data in the DHS resides. Users can access the data via one of two applications, both of which were developed by ECMWF:

- **Meteorological Archival and Retrieval System (MARS)**: a unique resource which allows research and operational staff to access and retrieve a wealth of meteorological data via a meteorological interface.
- **ECMWF Common File System (ECFS)**: a facility which allows users to store data that is not suitable for storing in MARS.

In 2007 the volume of primary data residing in the DHS, excluding backup copies, exceeded 6 petabytes and over 6 terabytes of data were being added daily.

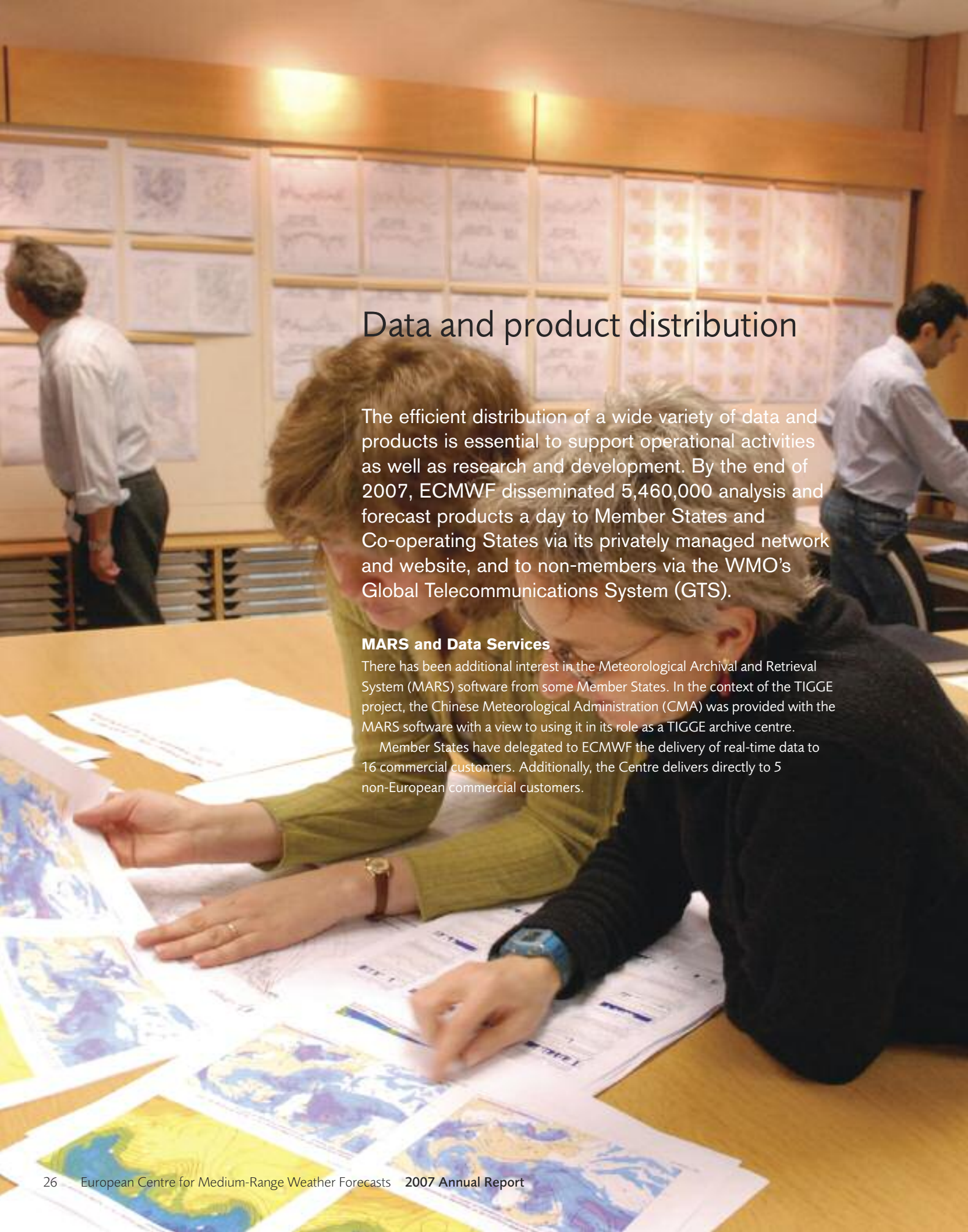
ECMWF holds a second copy of essential data in the Disaster Recovery System (DRS), in case the primary copy of the data was ever destroyed. This system is housed in a small building on-site, which is separate from the main computer building. It comprises servers, an automated tape library, tape drives and tape cassettes. In 2007 there were about 2 petabytes of data stored in the DRS.

In February 2007 a new IBM TS3595 automated tape library with twenty LTO-3 tape drives was installed in the DRS Building. This replaced an obsolescent ADIC AML/J automated tape library with its LTO-2 tape cassettes, which was installed in 1999. The new tape drives can store up to 400 gigabytes of data on LTO-3 tape cassettes, and are capable of reading from and writing to the previous generation of LTO-2 tape cassettes that can hold just half that amount.

SIMDAT

The EU-funded SIMDAT project is concerned with data grids for process and product development using numerical simulation and knowledge discovery. ECMWF is a partner in this project and is leading the development of the meteorology application. The objective is to develop an infrastructure, the Virtual Global Information System Centre (VGISC), which offers meteorologists and researchers a virtual view of all meteorological data distributed in real-time and the data in the archived databases of the partners. It will also provide a secure and reliable mechanism to collect, exchange and share these distributed data.

During 2007, development efforts mainly went into the Virtual Organisation by adding support for user management and data policies. At the end of 2007, the SIMDAT project was entering its final phase.



Data and product distribution

The efficient distribution of a wide variety of data and products is essential to support operational activities as well as research and development. By the end of 2007, ECMWF disseminated 5,460,000 analysis and forecast products a day to Member States and Co-operating States via its privately managed network and website, and to non-members via the WMO's Global Telecommunications System (GTS).

MARS and Data Services

There has been additional interest in the Meteorological Archival and Retrieval System (MARS) software from some Member States. In the context of the TIGGE project, the Chinese Meteorological Administration (CMA) was provided with the MARS software with a view to using it in its role as a TIGGE archive centre.

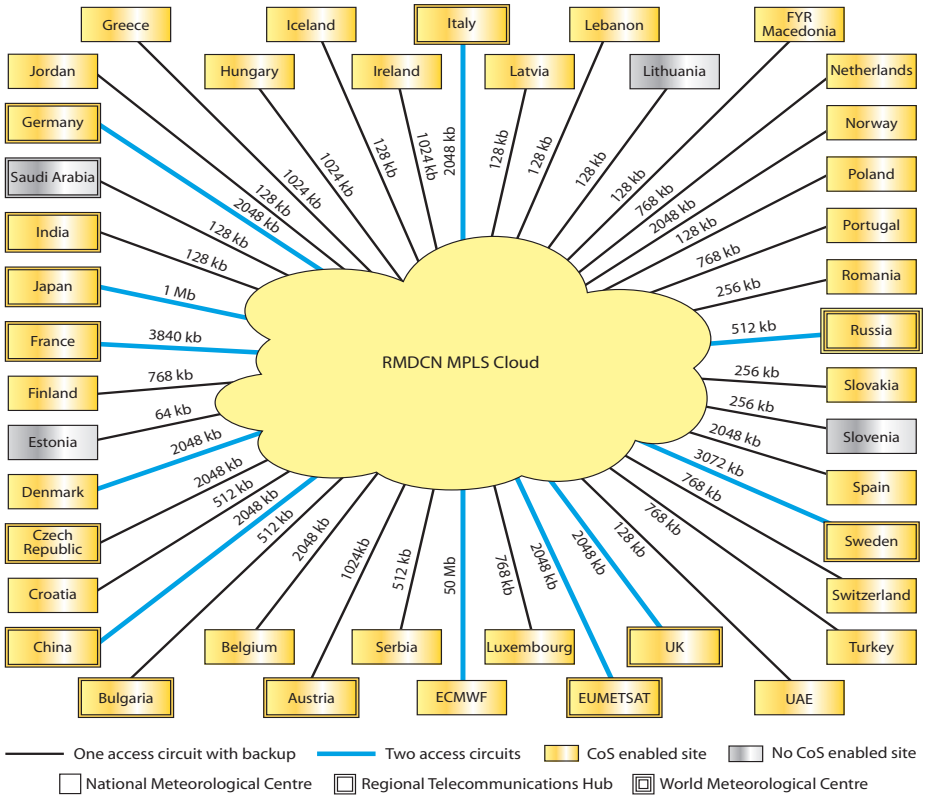
Member States have delegated to ECMWF the delivery of real-time data to 16 commercial customers. Additionally, the Centre delivers directly to 5 non-European commercial customers.

Regional Meteorological Data Communications Network

The Regional Meteorological Data Communications Network (RMDCN) has been in operation since March 2000. It provides a network infrastructure for the connections between ECMWF and its Member States and Co-operating States. In addition it has most of the GTS connections for WMO Regional Association VI. Over time it has expanded to encompass the Far East with connections to Japan, China and India. At the end of 2007, 42 user sites were connected to the RMDCN. ECMWF manages the project and monitors the network on behalf of the connected user sites following an agreement with WMO.

On 18 June 2007 a new milestone was reached for the RMDCN with the successful completion of the migration from a Frame Relay architecture to a new IPVPN (Internet Protocol Virtual Private Network) architecture based on MPLS (Multi Protocol Label Switching).

The RMDCN is now based on a state-of-the-art MPLS IPVPN architecture that has several advantages over Frame Relay: the network provides any-to-any connectivity between members of the RMDCN community; the access speed has doubled for the same charge; an improved backup service is providing a higher service availability; the provision of Class of Service (CoS) allows prioritization of various types of network traffic.



***RMDCN configuration in June 2007**. Shown are the new MPLS IPVPN network, the types of circuits and the backup configuration levels of the sites.*

The implementation of the new network started in May 2006, following the amendment of the contract with the network provider, Orange Business Services, which specified the new service levels and a detailed implementation plan. The new MPLS network was built in parallel to the existing Frame Relay network, which continued to provide an uninterrupted service. Following extensive acceptance tests, the operational service was moved to the new network in June 2007.

The successful completion of the RMDCN migration project was a major step in improving data communications between ECMWF Member and Co-operating States, as well as within the meteorological community as a whole. It provides a state-of-the-art network infrastructure with improved service levels and allows for new services to be introduced. The new network infrastructure also offers opportunities for further countries to join.

Web services

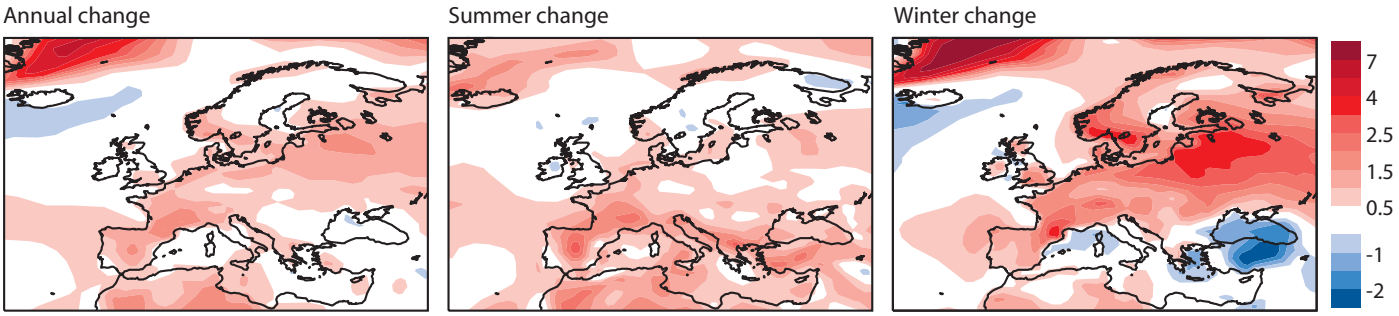
ECMWF's website is a major, easily accessible and much appreciated resource for the international meteorological and research communities. Users can access computer facilities and run experiments as well as accessing a wide range of information such as operational and research data, training material and data on special projects.

The ECMWF web servers continued to provide a stable and reliable service throughout 2007. The use of the website continues to grow, with an average growth of more than 60% per year in terms of the number of pages served. The growth rate of pages served to registered users is even higher.

The ECMWF web service hardware systems underwent a major upgrade during January 2007. These upgrades resulted in a significant improvement in the response of the web pages and provide scope for both additions of more content and web service enhancements in the future.

Other activities

ECMWF currently participates in a number of collaborative research programmes run by the European Union and WMO. Also it supports a variety of international meteorological activities. The Centre's computer resources and forecasting expertise are helping to improve the accuracy of global forecasting methods, develop new technologies for utilising computer and data storage capacity across distant sites, and improve atmospheric monitoring and forecasting for environmental and climate research.



***Linear trends in two-metre temperature (°C/50 years) over Europe for 1958 to 2001 from ERA-40**. The left-hand panel is for annual change, the middle panel is for summer (June, July August) and the right-hand panel is for winter (December, January, February). These charts show that ERA-40 analyses indicate that warming has occurred over Europe between 1958 and 2001.*

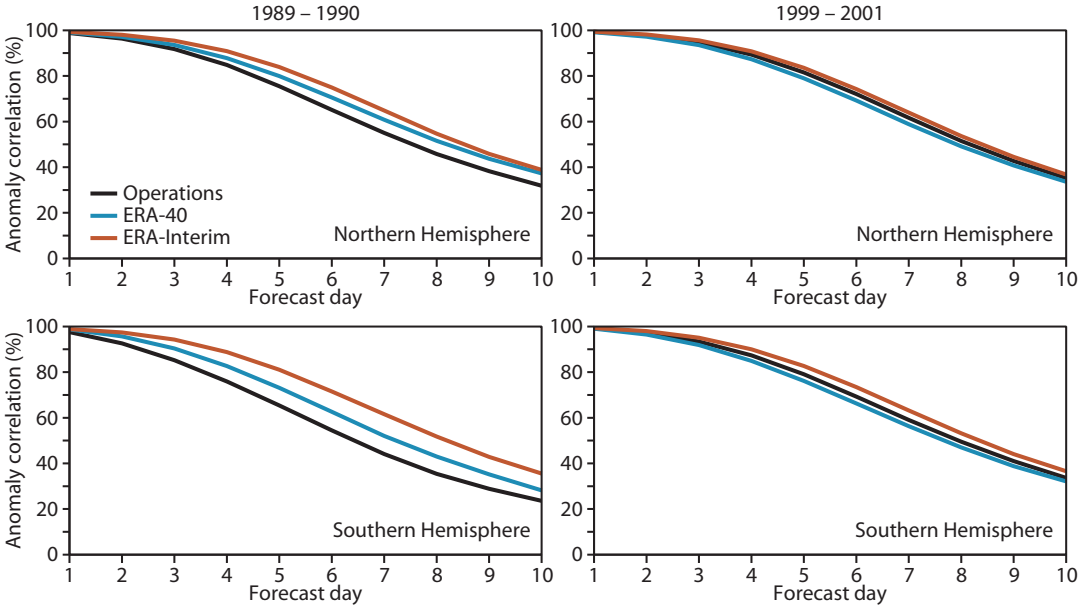
Reanalysis

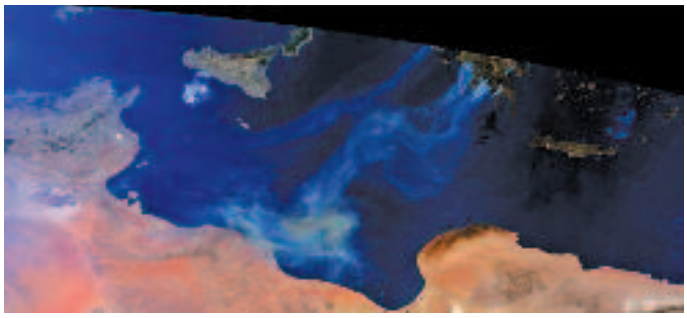
Over the past decade, reanalyses of multi-decadal series of past observations have become an important and widely utilized resource for the study of atmospheric and oceanic processes and predictability. Since reanalyses are produced using fixed, modern versions of the data assimilation systems developed for NWP, they are more suitable than operational analyses for use in studies of long-term variability of the climate. Reanalysis products are used increasingly in many fields that require an observational record of the state of either the atmosphere or its underlying land and ocean surfaces. Estimation of renewable energy resources, calculation of microwave telecommunication signal losses and study of bird migration are just three examples.

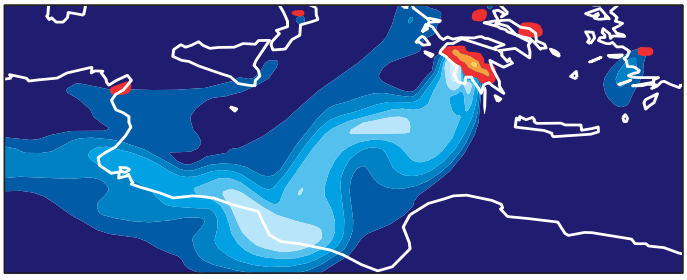
Two major ECMWF reanalyses have exploited the substantial advances made in the forecasting system and technical infrastructure since operations began at ECMWF in 1979. The first project, ERA-15 (ECMWF Reanalysis, 1979–1993), was completed in 1995 and the second extended reanalysis project, ERA-40 (1957–2002), in 2002. Products from ERA-15 and ERA-40 have been used extensively by the Member States and the wider user community. They are also increasingly important to many core activities at ECMWF, particularly for validating long-term model simulations, helping develop a seasonal forecasting capability, and establishing the climate of EPS (Ensemble Prediction System) forecasts needed for constructing forecaster-aids such as the Extreme Forecast Index.

ECMWF is currently producing ERA-Interim, a new global reanalysis of the data-rich period since 1989. The ERA-Interim system is based on a recent release of the Integrated Forecast System (IFS Cy31r2) containing many improvements both in the forecasting model and analysis methodology. Reanalysis of the period 1989–2001 was completed during 2007 and the system is expected to catch up with operations in late 2008. The reanalysis will then be continued in near real-time with the same system in order to support climate monitoring.

***A comparison of the skill of 500 hPa geopotential height forecasts**. The variation of anomaly correlation with forecast time provides a good measure of the quality of tropospheric analyses. The skill of the forecasts based on ERA-Interim is better than that for ERA-40 and operations.*







***Observed and modelled smoke plumes from the Greek fires at 0935 UTC on 26 August 2006**. The top plot is a true colour image observed by the MODIS instrument on-board the Terra satellite; the bottom plot shows the optical depth of the smoke plumes simulated by the GEMS aerosol model (bluish) and the Fire Radiative Power (FRP) observed by SEVIRI on-board Meteosat-9 (reddish). The FRP is interpolated to the model resolution. It has been used to estimate the smoke emission into the atmosphere. The transport and sink processes are subsequently simulated by the GEMS model. Individual plumes can be resolved because of the high temporal frequency of the SEVIRI observations. The detailed features of the simulated plumes demonstrate the accuracy of the transport in the ECMWF IFS. The model resolution in this example is 25 km. The simulation is a result of the collaboration in the FREEVAL project.*

GEMS/MACC

The EU-funded project GEMS, which is concerned with the global and regional Earth-system monitoring using satellite and in-situ data, began in 2005 as a contribution to the Global Monitoring for Environment and Security (GMES) initiative. GEMS is developing an atmospheric monitoring service which will generate valuable new global monitoring of greenhouse gases, reactive gases and aerosols, and produce regional short- and medium-range forecasts indicating air quality and pollution patterns across Europe. The four-year project is coordinated by ECMWF, which is also responsible for developing and operating the global assimilation and forecasting system for atmospheric composition.

Good progress continues to be made across all elements of ECMWF's contribution to GEMS. Retrospective global analyses for 2003 have been completed for all three groups of species, and prototype systems have been set up for the reactive gases and aerosols for near real-time. Technical support, including web display, has been provided for the participating European regional air-quality forecasting systems.

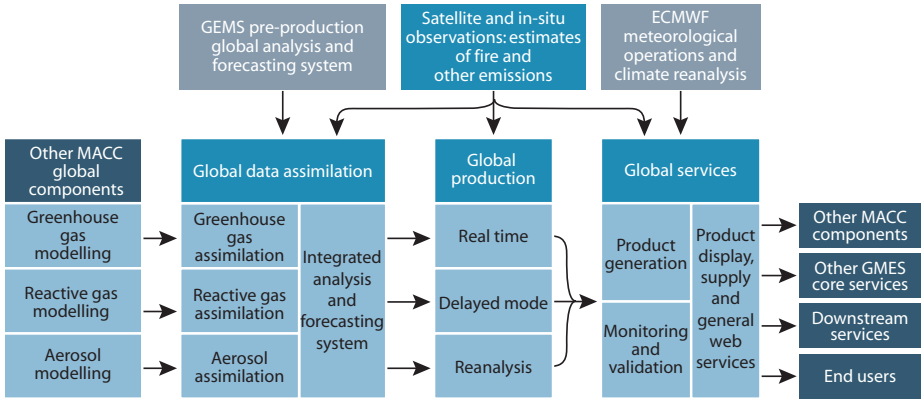
Amongst other products, GEMS will be able to provide real-time fire plume forecasts.

The Monitoring Atmospheric Composition and Climate (MACC) project was proposed to the European Commission in June. MACC is a successor not only to GEMS, but also to the ESA-funded GMES Service Element project PROMOTE. MACC is expected to start in 2009. The proposal was evaluated during the summer and the hearing took place in September. Contract negotiations have begun.

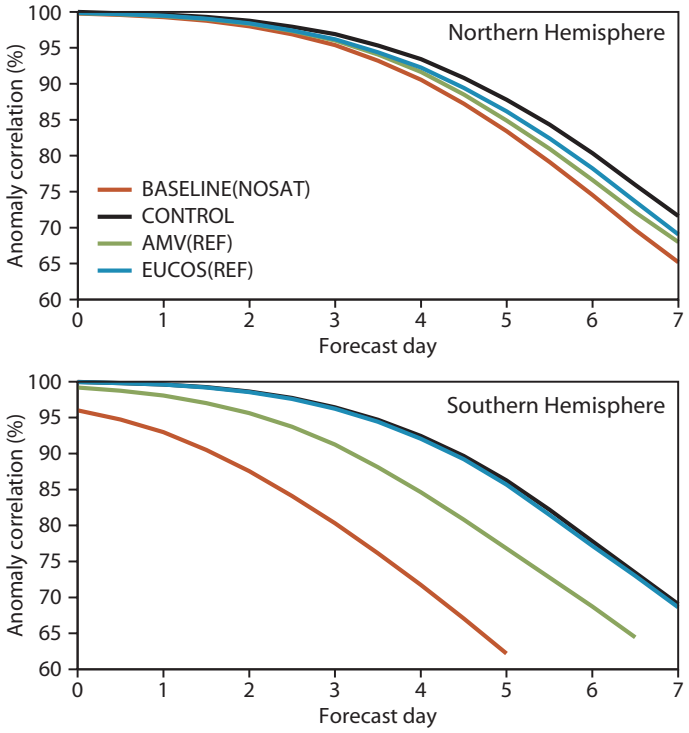
MACC was proposed by a partnership of 45 national institutes from 18 European States, plus ECMWF and the EU's Joint Research Centre. Partners include 11 Meteorological Services from Member and Co-operating States of ECMWF. Supporting organisations include EUMETSAT and WMO. ECMWF is the project coordinator and leader of components on global data assimilation, production and services, on data acquisition and on emissions from fires.

MACC will provide a range of data products and services:

- Satellite-data retrievals from several instruments for several aspects of atmospheric composition.
- Global analyses and reanalyses of greenhouse gases, reactive gases and aerosols.
- Global forecasts of reactive gases and aerosols.
- Estimates of global climate forcing, emissions and sinks.
- Regional multi-model forecasts and assessments of air quality.
- Specific services for stratospheric ozone, UV radiation solar-energy resources and in support of health protection.
- Estimates of long-range pollutant transport, source attribution, and support of international studies.



ECMWF's scientific and technical contributions to MACC.



***The mean anomaly correlation of 500 hPa geopotential height for a set of Observing System Experiments**. Results are given for the northern hemisphere (top panel) and southern hemisphere (bottom panel). Such experiments indicate the importance of satellite observations.*
BASELINE: All conventional observations used in NWP (radiosonde + aircraft + profiler network + surface land data + buoy observations + ship data).
CONTROL: Full operational observing system.
AMV(REF): BASELINE + Atmospheric Motion Vectors (AMVs) from polar and geostationary platforms.
EUCOS(REF): All satellite data + a reduced terrestrial observing system (i.e. GCOS upper-air and surface network).

Evaluation of the impact of various components of the Global Observing System

One of the goals of the ECMWF strategy is "to contribute towards the optimization of the Global Observing System (GOS)". In co-operation with EUMETSAT and EUCOS, a series of Observing System Experiments were performed in 2007, dedicated to examining the various components of the space and terrestrial components of the GOS.

There have been two sets of experiments. The first set aimed at evaluating the impact of the space component of the GOS in NWP, in the presence of a full terrestrial observational network. The second study assessed the added value of various components of the Terrestrial Observing System to the reduced upper-air and surface networks of GCOS (Global Climate Observing System) in the presence of all satellite observations.

The assessment of the space component of the GOS confirmed the crucial impact of satellite data on the performance of ECMWF's NWP system. The study also revealed that all the space-based sensors contribute in a positive way to the overall improvement of the ECMWF forecast system.

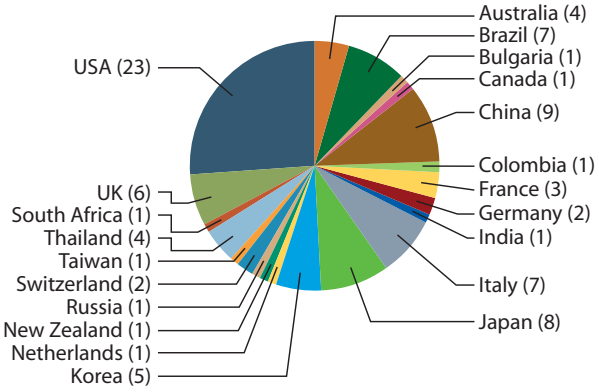
As for the influence of the terrestrial component of the GOS (which has been evaluated over Europe and the northern hemisphere), the study clearly indicated a large impact of radiosondes (wind and temperature) and aircrafts (wind and temperature), a marginal impact of radiosonde humidity information, and a neutral impact from the wind profilers.

EURORISK/PREVIEW project

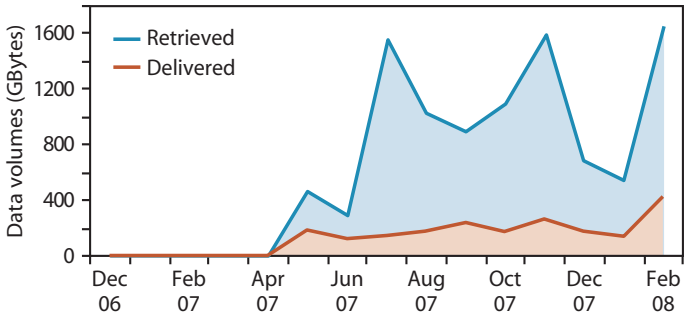
For the EURORISK/PREVIEW project a consortium of meteorological services, hydrological institutes and industrial partners are developing integrated solutions for early warning of severe weather. ECMWF contributes to two aspects of PREVIEW: the demonstration of the feasibility of targeted observations and the development of the European Flood Alert System.

Targeted observations are additional observations, taken at the request of the forecasters, for specific weather systems that appear difficult to predict. ECMWF has developed an automatized system allowing forecasters in the Member States to assess the potential impact of additional observations based on the observation sensitivity in the NWP forecasts of the day. The system allows the specification of a region of interest that can change every day, and the computation in real-time of the geographic areas where additional observations are most likely to influence the forecast in the region of interest. Additional observations in these areas can then be ordered from airplanes, commercial ships and radiosonde stations very easily. The system is currently in a year-long phase of pre-operational testing by the EUMETNET Composite Observing System (EUCOS) programme. EUMETNET is a network grouping of 24 European National Meteorological Services providing a framework to organise co-operative programmes between the members associated with basic meteorological activities.

The European Flood Alert System is being developed by the European Commission's Joint Research Centre and ECMWF. It is tailored to make good use of ECMWF medium-range ensemble forecasts of rainfall for early warning of severe floods from most large European rivers. The system is run for the whole of Europe at 5 km resolution and has benefited from reforecasts for its calibration. Additionally, ECMWF developed new products specifically meeting the needs of hydrologists, for example "RiverGrams". These are now produced routinely and show the most important variables averaged over river basins. New verification methods have also been developed. This has raised the visibility of ECMWF products among the hydrological users, and has prompted the demand for probabilistic products.



***Country of origin of registered users of the TIGGE archive**. Of the 89 registered users (excluding ECMWF internal users) about a third are active.*



***The amount of data retrieved from the TIGGE archive**. The blue line is the amount of data retrieved from the database, whilst the red line is the amount delivered to the users. The difference is due to the fact that users are given the possibility of extracting sub-areas and changing the resolution of the data retrieved.*

Co-operation with WMO

The range of products available to WMO Members has been extended to include the Extreme Forecast Index (EFI) and a wider selection of EPS Meteograms (EPSgrams). Since autumn 2007, over 70 countries have taken the opportunity to request additional EPSgrams.

ECMWF is supporting the WMO Severe Weather Forecast Demonstration Project in southern Africa. Forecast charts have been made available to participating weather services via the ECMWF website, including EFI maps and EPSgrams. Feedback from the Project Management Team has indicated that the ECMWF products have been well used during the project and have been valuable in predicting severe events.

ECMWF tropical cyclone tracks are being used in a new Pilot Project on Disaster Prevention and Mitigation, co-ordinated by the WMO Commission for Aeronautical Meteorology. The project will examine the potential benefits of tropical cyclone forecasts for aviation.

ECMWF scientists are also strongly involved in research projects developed under the WMO/IOC/ICSU World Climate Research Programme.

THORPEX/TIGGE

ECMWF continues to contribute actively to the WMO World Weather Research programme on THORPEX. A key component of THORPEX is TIGGE (THORPEX Interactive Grand Global Ensemble), which is aimed at enhancing international collaboration between operational centres and academia on the development of ensemble prediction. TIGGE will develop a deeper understanding of the contribution of observation, initial and model uncertainties to forecast errors. Also it will investigate new methods of combining ensembles from different sources and correcting systematic errors (biases and spread over- or under-estimation). TIGGE allows scientists around the world to access an archive of operational and research ensemble forecasts from a number of NWP centres.

The TIGGE project made rapid progress in 2007. As long series of forecasts from various providers were available in the TIGGE database, work started to compare the various systems and to evaluate the benefits of multi-model forecasts. Preliminary results showed that the ECMWF EPS has the best spread-error relation in the extra-tropics. In the tropics, the spread of all systems significantly underestimates the error. The ECMWF EPS is found to generally outperform other systems for probabilistic skill. The benefit of simple multi-model systems is found marginal in the extra-tropics, but significant in the tropics.

Around 240 GBytes (~1.6 million fields) are now exchanged routinely between several data producers and the three archive centres in near real-time. The operational feed of the TIGGE data archive started in October 2006. The TIGGE database now contains global ensemble forecast data from all ten data providers, and holds more than 100 TBytes of data (600 million fields).

ENSEMBLES

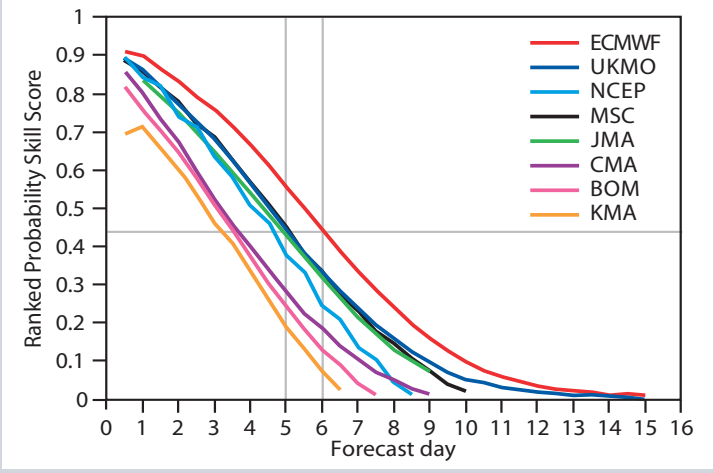
The representation of model uncertainty is a critical component in the development of reliable ensemble forecast systems. ECMWF is a key partner in the EU's ENSEMBLES project, and is developing and assessing different methods for representing model uncertainty in seamless forecast systems, across a range of prediction timescales from seasonal to decadal. At present the multi-model concept (see p 20) appears to provide the most skilful representation of model uncertainty, but other methods such as stochastic parametrization and perturbed parameters have also been shown to have considerable skill and hold great promise for future development.

The 15-day VarEPS and TIGGE

The performance of the ECMWF 15-day Variable Resolution Ensemble Prediction System (VarEPS, implemented at ECMWF in November 2006), has been compared with the performance of the global ensemble systems available within TIGGE. During 2007, TIGGE data started flowing to the TIGGE archive, and in December 2007 ten meteorological centres were sending data.

Results indicate that there is a large difference between the performance of the single ensembles. For 500 hPa geopotential height over the northern hemisphere, in the medium-range (say around forecast day 5) the difference between the worst and the best control or ensemble-mean forecasts is about 2 days of predictability, while the difference between the worst and the best probabilistic predictions can be larger, about 3 days of predictability.

Work has started on the quantification of the difference between the skill of the ECMWF ensemble and a combined ensemble generated using up to four different ensemble systems (including that of ECMWF). Initial results indicate that the difference is very small in areas where the ECMWF ensemble system has a well tuned ensemble spread, such as in mid-latitudes.



***Average Ranked Probability Skill Score for the probabilistic prediction of 500 hPa geopotential height over the northern hemisphere**. Results are given for ensembles from ECMWF, UK Met Office (UKMO), National Centers for Environmental Prediction (NCEP), Meteorological Service of Canada (MSC), Japanese Meteorological Administration (JMA), Chinese Meteorological Administration (CMA), Bureau of Meteorology (BOM) and Korean Meteorological Administration (KMA), each verified against its own analysis, for October and November 2007. Such comparisons show the high quality of ECMWF's VarEPS forecasts.*

GMES and GEO

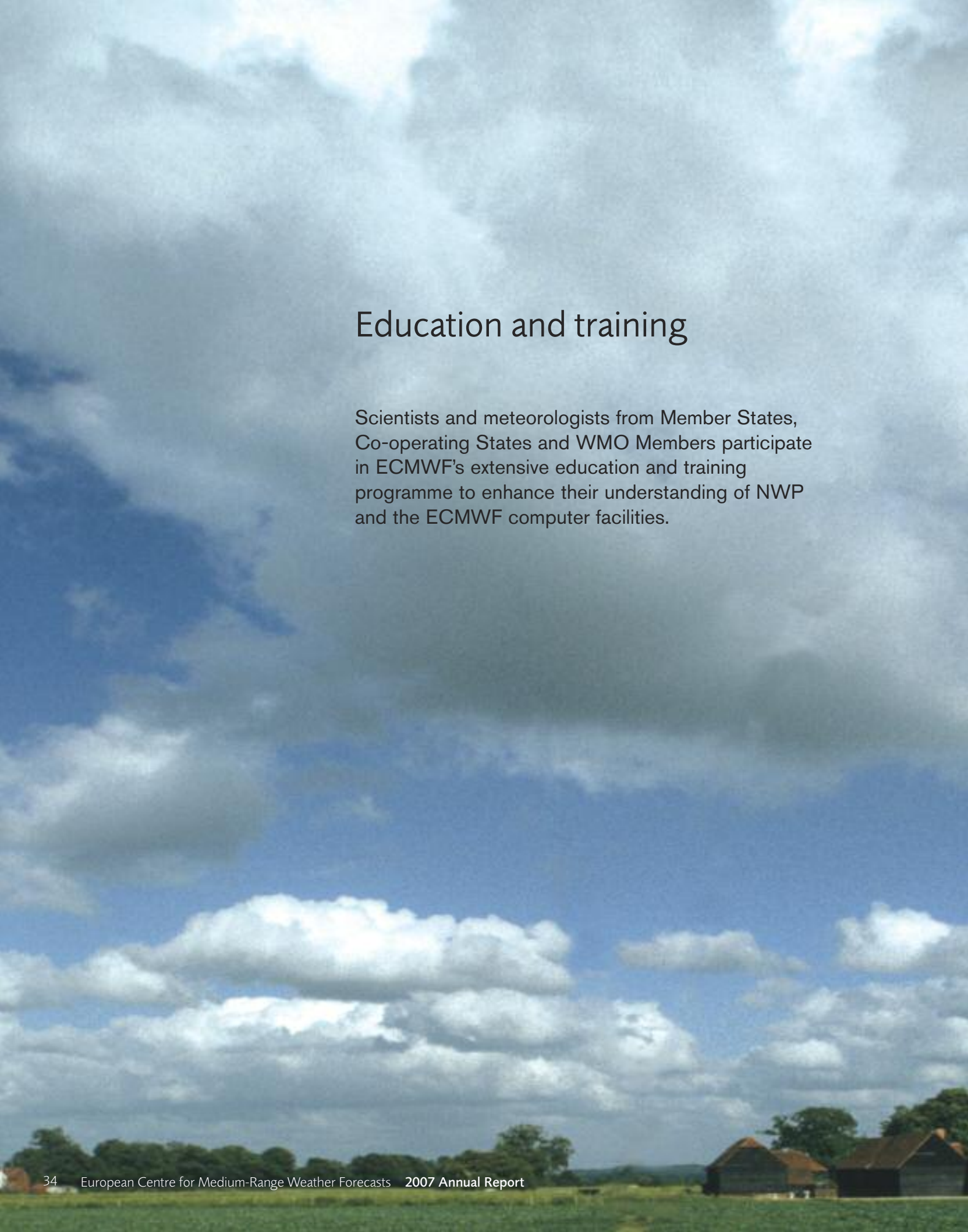
During 2007, ECMWF continued contributing to the development of the Global Monitoring for Environment and Security (GMES) initiative as well as to the Group on Earth Observation (GEO). GMES aims to make environmental information more readily available to scientists, policy-makers and industry, and to create a European shared information system for exchanging a wide range of information. GEO is leading a worldwide initiative to build a Global Earth Observation System of Systems (GEOSS) over the coming years. ECMWF is a Participating Organisation to GEO.

The concept of the GMES Atmosphere Service (GAS) was adopted at a meeting of the GMES Advisory Council (GAC) in Brussels on 14 February 2007 which was attended by the Director.

The Director attended a symposium on "The way to the European earth observation system GMES - Munich roadmap", organised by the German Federal Ministry of Transport in Munich on 17 April. An informal GAC meeting dedicated to the in-situ component of GMES, which took place on 13 September, was also attended by the Director.

ECMWF's contribution to GEO activities in 2007 included the provision of impact studies and simulations concerning the protection of radio-frequencies essential for tropospheric sounding, and for passive measurements in particular.

ECMWF made significant contributions to the activities of the GEO User Interface Working Group, the GEO Science and Technology Working Group and the Task Force set up by the GEO Secretariat to prepare the Ministerial Summit on 30 November 2007. Also ECMWF attended the GEO-IV Plenary on 28–29 November 2007 and the GEO Ministerial Conference on 30 November 2007 in Cape Town. Two articles by ECMWF staff were included in the GEO publication "The full picture", which was distributed at the GEO summit.



Education and training

Scientists and meteorologists from Member States, Co-operating States and WMO Members participate in ECMWF's extensive education and training programme to enhance their understanding of NWP and the ECMWF computer facilities.

Meteorological Training Courses

ECMWF conducts courses throughout the year which are designed to provide meteorologists of Member States and Co-operating States with advanced training in NWP and the use and interpretation of ECMWF products. An additional course is organised for participants from WMO National Meteorological and Hydrological Services that are not ECMWF Member States or Co-operating States.

As in previous years, the 2007 Meteorological Training Courses comprised the following modules.

- **Use and Interpretation of ECMWF products**
  (organised by the Operations Department)
  - 12-16 March: Use and interpretation of ECMWF products (repeated 4–8 June)
  - 15-19 October: Use and interpretation of ECMWF products for WMO Members
- **Numerical Weather Prediction**
  (organised by the Research Department)
  - 19-28 March: Numerical methods, adiabatic formulation of models
  - 16-24 April: Predictability, diagnostics and seasonal forecasting
  - 25 April-4 May: Data assimilation and use of satellite data
  - 8-18 May: Parametrization of diabatic processes

The Centre received 147 applications for one or more modules of the Meteorological Training Courses from 17 Member States, and 16 applications from Co-operating States and organisations with which ECMWF has a working agreement. In addition, applicants were accepted from 2 non-Member States.

The Centre received 11 applications for the WMO-sponsored course on the use and interpretation of ECMWF products for WMO Members, all of which were accepted.

Computer Training Course

The Computer Training Course was held from 8 February to 9 March. It comprised five independent modules:

- Introduction to the Supervisor Monitor Scheduler for workflow management
- Introduction to the Meteorological Archival and Retrieval System (MARS) for new users
- The Meteorological Application Graphics Integrated Colour System (MAGICS)
- The Metview graphics system
- Use of ECMWF's supercomputer resources

Forty-five participants from 18 Member States, Co-operating States and other organisations attended the Computer Training Course this year. The material presented during the training course has been made available on the ECMWF website.

Users' Meeting

The annual meeting for users of ECMWF's medium-range and extended-range products was held from 13 to 15 June. This gave forecasters the opportunity to discuss their experience with, and to exchange views on, the use of the Centre's products, review the development of the system, and discuss future developments. Over 40 delegates participated in this meeting. ECMWF staff provided information on the status and development of the operational forecasting system. Also users and developers gave presentations on the applications of medium- and extended-range forecasts as well as reporting on their use and evaluation.

Annual Seminar

The theme of this year's annual seminar, held from 3 to 7 September, was 'recent developments in the use of satellite observations in Numerical Weather Prediction'.

Over the past ten years, satellite observations have become the predominant source of information assimilated in NWP models. This seminar provided a review of the recent advances and future challenges in the use of satellite data.

Topics covered at the seminar included the exploitation of hyperspectral infrared sounders, the assimilation of cloud and rain-affected radiances and the opportunities offered by future satellite instruments for environment monitoring. Although focussed on the atmosphere, this seminar also provided a state-of-the-art review of satellite data assimilation for ocean and land applications.

Presentations were given by 15 invited lecturers and 8 members of ECMWF. The seminar was attended by 32 participants from Member States.

EUMETCAL blended learning course

The second EUMETCAL blended learning course was devoted to NWP for forecasters, and delivered by the Finnish Meteorological Institute in collaboration with the Norwegian Meteorological Institute, ECMWF, Deutscher Wetterdienst and the Austrian Zentralanstalt für Meteorologie und Geodynamik from 22 October to 14 December.

The participants attended weekly on-line distance lessons from various parts of Europe and met for four days in Langen, Germany, for a face-to-face session. The course covered different aspects of the operational use of NWP products in weather forecasting with leading experts in the field.

Workshops and meetings

Workshops and meetings provide the opportunity for experts from around the world to get together to exchange ideas, discuss the latest research and debate future developments.

ECMWF Workshop on Verification

ECMWF hosted the third International Workshop on Verification Methods from 29 January to 2 February.

The workshop counted 131 participants from 32 National Meteorological and Hydrological Services, 3 international organisations, 13 governmental agencies, 11 universities and 3 private weather service providers. It was sponsored by the World Weather Research Programme (WWRP), European Co-operation in the Field of Scientific and Technical Research (COST) and World Climate Research Programme (WCRP).

From the workshop it was clear that:

- Verification is a key component of any forecasting system as it helps monitor both its quality and value, and can be used to provide background information for decision makers.
- A hierarchy of verification methods is required which reflects the wide variety of users' needs.
- The scientific community should work in close contact with the user community to design verification strategies.

Verification of extreme events was considered. It was recognised that this is a difficult issue because of under-sampling, large uncertainties and noisiness due to the rarity of these events.

Expert Meeting on 'Unified VarEPS-monthly forecast product definition and scheduling'

An expert meeting dealing with the unified VarEPS-Monthly Forecast system took place on 8 and 9 May with 22 participants from Member States and Co-operating States. They discussed the configuration and the product requirements for the future unified system. Also valuable feedback was given on the plans presented to them.

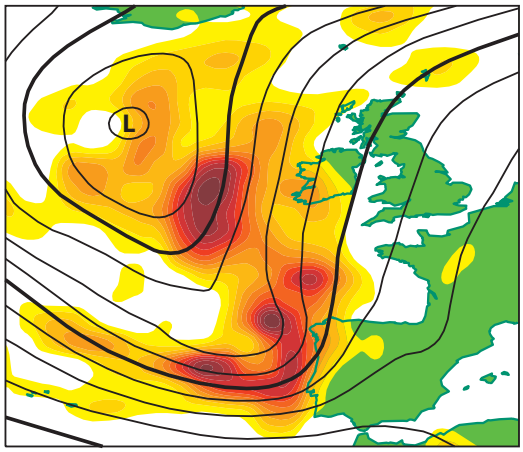
Meetings of Security Representatives and Computer Representatives

The annual meetings of the Security Representatives and the Computing Representatives took place at ECMWF from 21 to 24 May 2007.

Twenty-four participants attended the Security Representatives' Meeting and discussed various aspects of computer security. Technical issues were addressed as well as the management of security (e.g. Security Policy, Quality Management).

The Computing Representatives' Meeting provided a forum where views and experiences were exchanged between ECMWF and the Member States and Co-operating States. It was attended by 30 delegates. Recent changes and future development of ECMWF's computing service were discussed, as well as developments in the computing facilities in the delegates' organisations.

A six-hour forecast of a developing storm with an indication of the uncertainty. *The contours are the 300 hPa geopotential height with the orange-red shading signifying uncertainty in the model-produced "first guess" fields. Ensemble-based methods are well suited to detect and track these areas of higher observation significance as they evolve and develop.*



Workshop on "Flow-dependent aspects of data assimilation"

A three-day workshop on "Flow-dependent aspects of data assimilation" took place from 11 to 13 June.

The aim of the workshop was to bring together European and American experts to discuss ways in which the ECMWF analysis could be made more responsive to observations in those particular locations where significant and potentially severe weather is developing. These locations vary from day to day depending on the 'flow', i.e. the atmospheric conditions. It is where the model uncertainty is large that good observations can provide the most beneficial corrections to the model fields through flow-dependent data assimilation.

The working groups discussed the techniques for running ensembles of assimilations, including how the various sources of error could be represented and accounted for. The workshop recommendations will influence ECMWF's research plans in this area by suggesting the avenues to explore and the priorities for the next couple of years.

The workshop was attended by 11 invited lecturers and 4 ECMWF lecturers. In addition 22 participants from the Member States attended the lectures, some of whom attended the working groups.

Forecast Products Users Meeting

The annual meeting for users of ECMWF's medium-range and extended-range products was held from 13 to 15 June. It gave forecasters the opportunity to: discuss their experiences with, and to exchange views on, the use of medium-range and extended-range products, including the Ensemble Prediction System (EPS). Also they were able to review the development of the operational forecasting system and discuss plans for future changes, including the development of new forecast products.

Participants included operational forecasters from National Meteorological Services, commercial providers and academic users involved in developing products and assessing predictability at different timescales. Examples of the growing range of applications were presented from a variety of sectors, including energy, media, transport, health and water management (e.g. drought planning and flood risk assessment).

Third EUMETCAL Workshop

From 29 to 31 August 2007, ECMWF hosted the third EUMETCAL Workshop. Trainers from National Meteorological Services, EUMETSAT, ECMWF and interested parties met to discuss and learn about future developments in training. For the first time hydrologists attended a EUMETCAL Workshop.

The main topics covered by the presentations and round table discussions were the advances in modern training strategies and technologies. In particular there were discussions about how to incorporate newly available on-line learning tools, which enable highly interactive virtual classroom learning, into existing "face-to-face" training structures. In other words how to achieve the ultimate goal of delivering blended learning in an optimal way.

During the workshop the opportunity was taken to inform participants about operational and research activities at ECMWF. The workshop was attended by 24 participants.

***Intercommission Coordination Group on WIS**. Participants in the session of the Intercommission Coordination Group on the WMO Information System (WIS) which was held at ECMWF from 4 to 7 September 2007.*

Annual session of the Intercommission Coordination Group on WIS

From 4 to 7 September 2007 ECMWF, jointly with the UK Met Office, hosted the annual session of the Intercommission Coordination Group on the WMO Information System (WIS).

The WIS is being developed as an overarching information system for the collection and sharing of information for all WMO and related international programmes. Twenty-four delegates comprising representatives from various WMO Programmes, WMO Regional Associations and CBS Expert Teams met to review the requirements and the implementation plan, and agree on further developments.

Workshop on Ensemble Prediction

A Workshop on ensemble prediction was held at ECMWF from 7 to 9 November 2007. The workshop reviewed the most recent advances in ensemble techniques applied to data-assimilation and forecast systems for predictions ranging from days, through months and seasons, to multi-annual timescales. Topics discussed included:

- Representation of initial uncertainties (ensemble data assimilation, ensemble transform Kalman filter, bred vectors, singular vectors etc.).
- Representation of model uncertainties (multi-model ensembles, perturbed parameter ensembles, stochastic parametrization etc.).
- Validation and calibration methods.
- Applications of ensemble forecasts.

Results of theoretical and practical research, using both global and limited area models, were included in the presentations.

Lessons drawn from intercomparisons of results on different timescales, as encouraged in the World Climate Research Programme's Strategic Framework on seamless prediction, were the focus of discussions at the workshop.

Presentations were given by 17 invited lecturers and 2 ECMWF lecturers, and some 30 invited observers attended the workshop.

Workshop on Meteorological Operational Systems

The 11th biennial Workshop on Meteorological Operational Systems was held from 12 to 16 November 2007.

The objective of the workshop was to review the state-of-the-art of meteorological operational systems and to address future trends in:

- Use and interpretation of medium and extended range forecast guidance.
- Operational data management systems.
- Meteorological visualisation applications.

The workshop proved to be very popular with over 80 participants from ECMWF Member States and Co-operating States, and from other parts of Europe and beyond.

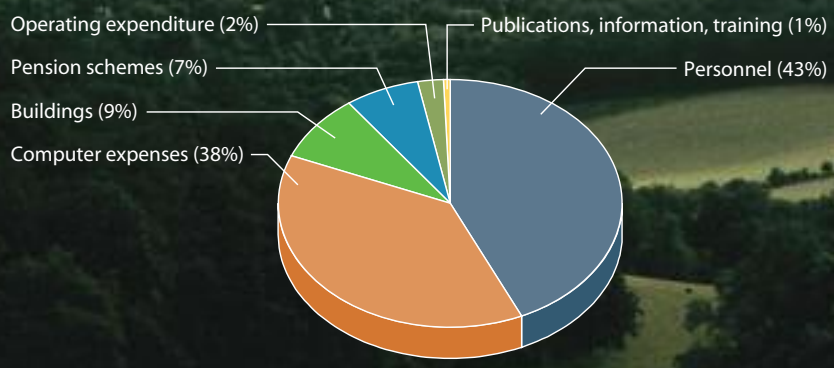
Administrative matters

To ensure that ECMWF can fulfil its strategic aims it is necessary to ensure that appropriate staff, facilities and funding are in place. The opening of the new office block and reaching agreement about the funding of the High Performance Computing Facility (HPCF) were major achievements during the year.

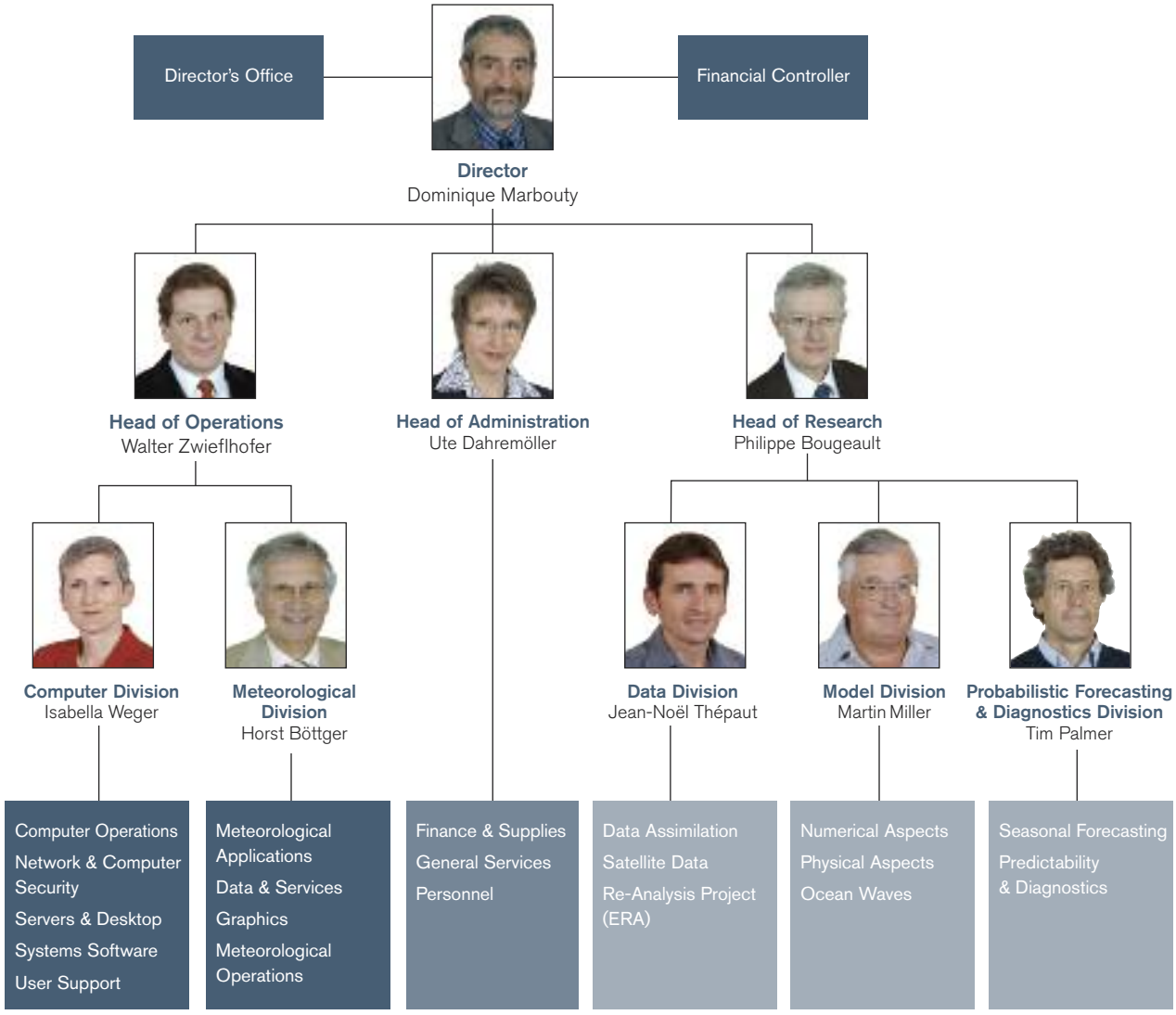
Finance

ECMWF's budget for 2007 was £31,043,200, which included contributions from Member States and Co-operating States amounting to £29,555,000 and miscellaneous revenue of £1,488,200. The main expenditure was on the high performance computer infrastructure and staff.

At its meeting in December 2007, the Council agreed that Member States' contributions to the budget for 2008 would increase by 3.0% over the budget for 2007. Also it was agreed to increase the budget for the HPCF by £1 million from 2011 on top of the additional £3.5 million from 2009 onwards already agreed in December 2006.



The Centre's Organisation at 31 December 2007



Personnel

ECMWF's Director, appointed by the Council, is responsible for implementing the organisation's objectives and oversees three departments: Operations, Research and Administration.

At December 2007, ECMWF employed 157 staff members, 68 consultants and 32 contractors. During the year, 12 staff members were recruited, 5 staff members left the organisation and 3 staff members retired.

ECMWF operates an equal opportunities policy. Staff and consultants are recruited solely on the basis of their qualifications and experience, and not on their gender, marital status, race or religion.

It was with great sadness that we had to announce the sudden death of Tony Hollingsworth, who passed away on Sunday 29 July 2007.

Grade/Year	2002	2003	2004
B-Grades	51%	47%	48%
A-Grades	11%	13%	14%
	2005	2006	2007
B-Grades	49%	50%	49%
A-Grades	16%	17%	17%

Proportion of female staff employed by ECMWF 2002–2007.

Tony Hollingsworth, 1943–2007

Tony began his career working as a forecaster in the Irish Meteorological Service, from which he took leave to carry out PhD studies at M.I.T. He returned to Europe to take up a research position in the UK Universities' Atmospheric Modelling Group at the University of Reading. He joined ECMWF on 1 March 1975 and was the Centre's longest serving member of staff.

In his time at ECMWF he worked on virtually every aspect of NWP, heading in turn the Physical Aspects Section and the Data and Model Divisions of the Research Department. He was appointed Head of Research in 1991 and Deputy Director in 1995. He stepped down from these positions on reaching his sixtieth birthday, but eschewed retirement to lead the Europe-wide GEMS environmental monitoring project, an activity he pursued with vision and dedication to the very end.

Tony was an important player on a wider international stage, fostering extensive collaboration with EUMETSAT, ESA and space agencies worldwide. Also he supported the World Climate Research Programme, the Global Climate Observing System, the US National Academy of Sciences and the American Meteorological Society. He was a recipient of the Jule G. Charney Award, and a DSc of the University of Cork for his contributions to NWP.

The cutting of the ribbon at the inauguration of ECMWF's new office block *by Councillor Annette Drake (The Worshipful the Mayor of Wokingham Borough), Mr Dominique Marbouty (Director of ECMWF) and Dr Adérito Vicente Serrão (President of the ECMWF Council).*

ECMWF's new courtyard.

Facilities

ECMWF celebrated the inauguration of the new office block at its Headquarters at Shinfield Park, Reading, on 28 June 2007. The event was attended by delegations of ECMWF Member States and Co-operating States, representatives of the UK Government, prominent representatives of the scientific meteorological community and officials from local authorities.

The following speakers addressed the auditory (see picture below, left to right):

- Dr Adérito Vicente Serrão, President of the ECMWF Council
- Dr Lars Prahm, Director-General of EUMETSAT
- Mr Dominique Marbouty, Director of ECMWF
- Councillor Annette Drake, The Worshipful the Mayor of Wokingham Borough
- Mr Michel Jarraud, Secretary-General of WMO

The building provides a new home for a major part of ECMWF's Research Department. It provides staff and consultants with excellent working conditions required, for instance, to further develop products for early warnings of severe weather events, improve seasonal forecasting, and engage in environmental issues such as climate monitoring.

The event coincided with the finishing of the landscaping between the old office building and the new office building where an attractive forecourt surrounded by extensive green areas was created. Furthermore, the area at the street entrance was cleared and re-designed so as to provide ECMWF with a more attractive and inviting entrance area. This clearly enhances its visibility for people passing by and thus helps to raise its local profile.

Amendments to the Convention

ECMWF was founded on 1 November 1975 with the purpose of developing a European capability for medium-range weather forecasting and providing medium-range weather forecasts to its Member States. The Convention establishing ECMWF sets out its core objectives and duties. It restricts membership to the founding 18 Member States.

In April 2005 the Council, the Centre's governing body, in a landmark decision, unanimously agreed to amend the Convention to facilitate ECMWF's activities as leading provider of global medium-range weather forecasts. All Member States must notify their acceptance of the amendments to the depositary of the ECMWF Convention, the Secretariat of the Council of the European Union, before they can enter into force. By the end of 2007, 11 Member States had done so.

- Finland: 12 July 2005
- Denmark: 17 March 2006
- Norway: 23 June 2006
- United Kingdom: 22 December 2006
- The Netherlands: 19 March 2007
- Switzerland: 3 May 2007
- Italy: 2 July 2007
- Spain: 6 July 2007
- Luxembourg: 12 July 2007
- France: 23 July 2007
- Sweden: 4 September 2007

When ratified by all the current Member States, the amended Convention will:

- Allow new Member States to join the organisation.
- Enlarge ECMWF's mission to cover the monitoring of the Earth-system.
- Broaden the possibility for activities funded externally.

Appendices

ECMWF's Member States and Co-operating States

Member States

Austria, Belgium, Denmark, Germany, Greece, Finland, France, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

Co-operating States

Croatia, the Czech Republic, Estonia, Hungary, Iceland, Lithuania, Montenegro, Morocco, Romania, Serbia, Slovakia (from 1 January 2008) and Slovenia.

Co-operating States have full access to ECMWF real-time products, archive data, software tools, as well as access to ECMWF training facilities.

During the reporting period, two co-operation agreements were signed with Montenegro and Slovakia. Montenegro became a Co-operating State on 5 November; the co-operation agreement with Slovakia will enter into force on 1 January 2008.

Co-operation agreements

ECMWF has co-operation agreements with the following organisations:

- World Meteorological Organization (WMO)
- European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT)
- European Space Agency (ESA)
- African Centre of Meteorological Applications for Development (ACMAD)
- Joint Research Centre (JRC) of the European Commission
- Preparatory Commission for the Comprehensive Nuclear Test-Ban Treaty Organization (CTBTO)
- Executive Body of the Convention on Long-range Transboundary Air Pollution (CLRTAP)

Council and committees

As ECMWF's governing body, and comprising two representatives from each Member State, the Council adopts measures that implement the Convention. Its responsibilities include admission of new members, authorising the Director to negotiate and conclude co-operation agreements, determining the annual budget and the scale of financial contributions of the Member States, adopting the Financial Regulations and the Staff Regulations and pursuing the Centre's long-term strategy and programme of activities.

ECMWF Council held its 67th session in Reading on 28–29 June 2007

The Council:

- Authorised the Director to conclude agreements with Israel and with Montenegro, and to start negotiations with Poland.
- Requested the Centre to further strengthen its relationship with the European Commission and its institutions.
- Adopted amendments to the Financial Regulations related to gender neutrality and to contributions from new Member States after entry into force of the amendments to the Convention.
- Adopted the setting up of a dedicated Pension Reserve Account for the Budgetised Pension Scheme.
- Agreed on a pricing of multimodel seasonal products (EUROSIP), on revised Rules for the provision of real-time data, and on modifications to the Catalogue of ECMWF real-time products. The Council further agreed to the removal of the Redistribution Licence Fee and adopted amendments to the Rules for the provision of archived data.
- Unanimously approved the reappointment of Mr Dominique Marbouty as Director for a three-year period until 30 June 2011, when he reaches the retirement age of 60, and the extension of the contract of Mr Walter Zwieflhofer as Head of Operations Department for a period of five years until 17 June 2013.
- Supported the Centre's 'Equal Opportunity Policy' which was presented by the Director.

ECMWF Council held its 68th session in Reading on 10–11 December 2007

The Council:

- Unanimously authorised the Director to enter into a service contract with IBM UK Ltd to replace the High Performance Computing Facilities at the Centre from 2009 onwards. The Council also agreed unanimously to increase the HPCF budget by £1 million from 2011 on top of the additional £3.5 million from 2009 onwards already agreed upon in December 2006.
- Unanimously adopted the updated "Four-Year Programme of Activities" for the period 2008–2011.

- Unanimously agreed that Member States' contributions to the Budget 2008 would increase by 3.0% over the Budget 2007.
- Unanimously adopted the investment policy as proposed by the Centre for the funds in the dedicated pension account of the Funded Pension Scheme.
- Agreed that the following points should be considered: review of the financial strategy; conduction of a technical risk analysis and the management of the identified risks; review of the strategic risk analysis and the management of the identified risks; consideration of the introduction of activity-based costing; development of a long-term solution for the pension issue; consideration of the introduction of International Public Sector Accounting Standards (IPSAS) and standards of the International Organisation of Supreme Audit Institutions (INTOSAI). The Council agreed to the Centre's road map to address these issues.
- Agreed on the calculation method of the Single Additional Contribution due for new Member States, in particular for former Co-operating States. New membership to ECMWF is possible when the amended Convention is ratified by all current Member States.
- Agreed to (a) make a subset of ECMWF wave products available to WMO Members in support of extreme sea state forecasting, and (b) to add several EUROSIP (EUROpean multi-model Seasonal-to-Interannual Prediction system) products to the Catalogue of ECMWF real-time products.

Member States' representatives to Council Sessions

President: Adérito Vicente Serrão (Portugal) **Vice-President:** Wolfgang Kusch (Germany)

State	Representatives	Advisers
Belgium	Henri Malcorps, Heidi Langenus	
Denmark	Peter Aakjaer, Leif Laursen	Esben Elbrønd-Bek
Germany	Wolfgang Kusch, Gerhard Adrian, Detlev Frömming	Christian Sperling
Greece	Odysseas Galanopoulos, Ioannis Papageorgiou, Maria Katsimardou-Refene	Eleni Georgopoulou
Spain	Jesus Patan	
France	Pierre-Etienne Bisch, Philippe Veyre	
Ireland	Tom Sheridan	
Italy	Massimo Capaldo, Pierluigi Cascioli	Sergio Pasquini
Luxembourg	Claude Alesch	
The Netherlands	Frits Brouwer	
Norway	Anton Eliassen, Øystein Hov, Roar Skålin	
Austria	Fritz Neuwirth	
Portugal	Adérito Vicente Serrão, Teresa Abrantes	
Switzerland	Daniel Keuerleber-Burk	Alex Rubli
Finland	Petteri Taalas, Mikko Alestalo	Juhani Damski
Sweden	Maria Ågren, Jörgen Nilsson	
Turkey	Adnan Ünal, Fatih Büyükkasabbaşi, Can Oğuz	
United Kingdom	Mark Hutchinson, John Hirst, Alan Dickinson	Phil Evans, Jim Sharp

Policy Advisory Committee (PAC)

The PAC provides the Council with opinions and recommendations on any matters concerning ECMWF policy submitted to it by the Council, especially those arising out of the Centre's four-year programme of activities and long-term strategy.

Chair: Massimo Capaldo (Italy)
Vice-Chair: Fritz Neuwirth (Austria)

Member States' representatives:

Germany	Wolfgang Kusch
Adviser	Detlev Frömming
Greece	Theodoros Kolydas
Spain	Bartolomé Orfila
France	Alain Ratier
Italy	Massimo Capaldo
Adviser	Sergio Pasquini
Austria	Fritz Neuwirth
Finland	Maria Hurtola
Sweden	Jörgen Nilsson
Switzerland	Mathias Rotach
United Kingdom	Alan Dickinson
Adviser	Jim Sharp

Finance Committee (FC)

The FC provides the Council with opinions and recommendations on all financial matters submitted to the Council and exercises the financial powers delegated to it by the Council.

Chair: Laurence Frachon (France)
Vice-Chair: Monika Köhler (Austria)

Member States' representatives:

Germany	Detlev Frömming
	Christian Sperling
Spain	Manuel Palomares
(also representing Greece, Portugal and Turkey)	
France	Christine Mengus
	Laurence Frachon
Ireland	Liam Campbell
(also representing Denmark, Norway, Finland and Sweden)	
Italy	Antonio Bartolini
	Sergio Pasquini
Austria (observer)	Monika Köhler
Switzerland	Peter Morscher
(also representing Austria, Belgium, The Netherlands, and Luxembourg)	
United Kingdom	Paul Mundy
	Jim Sharp

Scientific Advisory Committee (SAC)

The SAC provides the Council with opinions and recommendations on the draft programme of activities of the Centre drawn up by the Director and on any other matters submitted to it by the Council. SAC members are appointed in their personal capacity and are selected from among the scientists of the Member States.

Chair: Gerhard Adrian
Vice-Chair: Martin Ehrendorfer

Members:

Gerhard Adrian
François Bouttier
Luigi Cavaleri
Martin Ehrendorfer
John Eyre
Hans Huang
Heikki Järvinen
Hennie Kelder
Jochem Marotzke
Ernesto Rodriguez-Camino
Julia Slingo
Michael Tjernström

Technical Advisory Committee (TAC)

The TAC provides the Council with advice on the technical and operational aspects of the Centre including the communications network, computer system, operational activities directly affecting Member States, and technical aspects of the four-year programme of activities.

Chair: Kristiina Soini (Finland)
Vice-Chair: Alan Dickinson (United Kingdom)

Member States' representatives:

Belgium	Daniel Gellens
Denmark	Leif Laursen
Germany	Geerd-Rüdiger Hoffmann Henning Weber Dieter Schröder
Greece	Dimitrios Kapniaris
Spain	Pablo del Rio Fermin Elizaga
France	Bernard Strauss Matteo Dell'Acqua Jean-Marie Carrière
Ireland	Jim Logue
Italy	Sergio Pasquini
Luxembourg	Claude Alesch
The Netherlands	Toon Moene
Norway	Jens Sunde, Roar Skålin
Austria	Georg Kaindl
Portugal	Teresa M. Diniz Abrantes Victor Prior
Switzerland	Stefan Sandmeier Thomas Egli
Finland	Kristiina Soini, Pertti Nurmi
Sweden	Ilmar Karro, Håkan Borg
Turkey	Fatih Büyükkasabbaşi
United Kingdom	Alan Dickinson Alastair Price

Co-operating States' representatives:

Czech Republic	Martin Janoušek
Estonia	Tarmo Kaldma
Croatia	Ivan Čačić Čedomir Brankovič
Iceland	Halldor Björnsson
Lithuania	Saulius Balys
Hungary	Zoltán Dunkel Istvan Ihász
Morocco	Hassan Haddouch
Romania	Ion Victor Pescaru
Slovenia	Jure Jerman
Serbia	Ljiljana Dekic

Advisory Committee for Data Policy (ACDP)

The ACDP provides the Council with opinions and recommendations on matters concerning ECMWF Data Policy and its implementation.

Chair: Lillian Wester-Andersen (Denmark)
Vice-Chair: Colin Cuthbert (United Kingdom)

Member States' representatives:

Denmark	Lillian Wester-Andersen
Germany	Klaus Haderlein
Spain	Francisco Pascual Pérez
France	Christine Mengus Philippe Santoni
Ireland	Joseph Bourke
Netherlands	Ton Donker
Norway	Lillian Svendsen
Finland	Lea Leskinen
Sweden	Gunlög Wennerberg Marcus Flarup
United Kingdom	Colin Cuthbert Jim Sharp, Gil Ross

Co-operating State representative:

Croatia	Branka Ivančan-Picek

Advisory Committee for Co-operating States (ACCS)

The ACCS provides the Council with opinions and recommendations on the Centre's programme of activities, and on any matter submitted to it by the Council.

Chair: Jozef Roskar (Slovenia)
Vice-Chair: Ion Sandu (Romania)

Co-operating States' representatives:

Czech Republic	Radim Tolasz
Estonia	Jaan Saar, Aarne Männik
Croatia	Ivan Čačić Čedomir Brankovič Dijana Klarić Branka Ivančan-Picek Vlasta Tutiš
Hungary	Zoltán Dunkel
Serbia	Dragan Jovanović
Slovenia	Klement Bergant Jožef Roškar

Observers:

Bosnia and Herzegovina	Muhamed Muminović
Montenegro	Radivoje Vučković
Slovakia	Martin Benko

Publications in 2007

(Visit: www.ecmwf.int/publications/)

Peer reviewed publications

Andersson, **E.**, **E. Hólm**, **P. Bauer**, **A. Beljaars**, **G.A. Kelly**, **A.P. McNally**, **A. Simmons**, **J.-N. Thépaut** and **A.M. Tompkins** (2007): Analysis and forecast impact of the main humidity observing systems. *Q. J. R. Meteorol. Soc.*, **133**, doi: 10.1002/qj.112

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507 **Branković**, **Č.**, **B. Matjačić**, **S. Ivatek-Šahdan** and **R. Buizza**: Dynamical downscaling of ECMWF EPS forecasts applied to cases of severe weather in Croatia. (*January 2007*)

508 **Balmaseda**, **M.**, **A. Vidard** and **D. Anderson**: The ECMWF System 3 ocean analysis system. (*February 2007*)

509 **Bidlot**, **J.-R.**, **P. Janssen** and **S. Abdalla**: A revised formulation of ocean wave dissipation and its model impact. (*January 2007*)

510 **Tan**, **G.H.D.**, **E. Andersson**, **M. Fisher** and **L. Isaksen**: Observing system impact assessment using a data assimilation ensemble technique: application to the ADM-Aeolus wind profiling mission. (*January 2007*)

511 **Kelly**, **G.**, **J.-N. Thépaut**, **R. Buizza** and **C. Cardinali**: The value of targeted observations - Part I: Data denial experiments for the Atlantic and the Pacific. (*February 2007*)

512 **Buizza**, **R.**, **C. Cardinali**, **G. Kelly** and **J.-N. Thépaut**: The value of targeted observations – Part II: The value of observations taken in singular vectors-based target areas. (*February 2007*)

513 **Cardinali**, **C.**, **R. Buizza**, **G. Kelly**, **M. Shapiro** and **J.-N. Thépaut**: The value of targeted observations – Part III: Weather-regime sensitivity of the value of targeted observations. (*February 2007*)

514 **Leutbecher**, **M.** and **T. N. Palmer**: Ensemble Forecasting (submitted to *J. Comp. Phys.*). (*February 2007*)

515 **Benedetti**, **A.** and **M. Janisková**: Assimilation of MODIS cloud optical depths in the ECMWF model. (*February 2007*)

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518 **M.J. Rodwell** and **T.N. Palmer**: Using NWP to assess climate models. (*March 2007*)

519 **Leutbecher**, **M.**: On the representation of initial uncertainties with multiple sets of singular vectors optimised for different criteria. (*September 2007*)

520 **Trémolet**, **Y.**: Model error estimation in 4D-Var. (*March 2007*)

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523 **Kelly**, **G.**: The evaluation of the HIRS/4 instrument on Metop 2 by using the ECMWF data assimilation system to provide a reference to compare with other sensors. (*May 2007*)

524 **Abdalla**, **S.**: Ku-band radar altimeter surface wind speed algorithm. (*April 2007*)

525 **Matricardi**, **M.**: An inter-comparison of line-by-line radiative transfer models. (*May 2007*)

526 **Bouniol**, **D.**, **A. Protat**, **J. Delanoë**, **J. Pelon**, **D.P. Donovan**, **J.-M. Piriou**, **F. Bouyssel**, **A.M. Tompkins**, **D.R. Wilson**, **Y. Morille**, **M. Haeffelin**, **E.J. O'Connor**, **R.J. Hogan** and **A.J. Illingworth**: Evaluating cloud occurrence in the ECMWF integrated forecast system and three other operational forecasts models using long-term ground-based radar and lidar measurements. (*December 2007*)

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528 **Morcrette**, **J.-J.** and **A. Arola**: A processor to get UV-B and UV-A radiation products in/from the ECMWF IFS. (*June 2007*)

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535 **Geer**, **A.J.**, **P. Bauer** and **P. Lopez**: Lessons learnt from the 1D+4D-Var assimilation of rain and cloud affected SSM/I observations at ECMWF [also published as: EUMETSAT/ECMWF Fellowship Programme – Research Report RR17]. (*August 2007*)

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537 **Tan**, **D.G.H.**, **E. Andersson**, **J. de Kloe**, **G.-J.Marseille**, **A. Stoffelen**, **P. Poli**, **D. Huber**, **M.-L. Denneulin**, **A. Dabas**, **P. Reitebuch**, **H. Nett**, **P. Flamant** and **O. Le Rille**: The ADM-Aeolus wind retrieval algorithms. (*August 2007*)

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539 **Morcrette**, **J.-J.**, **P. Bechtold**, **A. Beljaars**, **A. Benedetti**, **A. Bonet**, **F. Doblas-Reyes**, **J. Hague**, **M. Hamrud**, **J. Haseler**, **J.W. Kaiser**, **M. Leutbecher**, **G. Mozdzynski**, **M. Razinger**, **D. Salmond**, **S. Serrar**, **M. Suttie**, **A. Tompkins**, **A. Untch** and **A. Weisheimer**: Recent advances in radiation transfer parametrizations (presented to the 36th Session of the SAC, 8–10 October 2007). (*October 2007*)

540 **Palmer**, **T.N.**, **R. Buizza**, **M. Leutbecher**, **R. Hagedorn**, **T. Jung**, **M. Rodwell**, **F. Vitart**, **J. Berner**, **E. Hagel**, **A. Lawrence**, **F. Pappenberger**, **Y.-Y. Park**, **L. von Bremen**, **I. Gilmour**: The Ensemble Prediction System – recent and ongoing developments (presented to the 36th Session of the SAC, 8–10 October 2007). (*October 2007*)

541 **Prior**, **P.** (Compiler): Report on the 15th Security Representatives' Meeting, 21–22 May 2007. (*October 2007*)

542 **Prior**, **P.** (Compiler): Report on the 19th meeting of Computing Representatives, 22–24 May 2007. (*March 2008*)

543 **Orr**, **A.** and **P. Bechtold**: Improvement in the capturing of short-range warm season orographic precipitation in the ECMWF model. (*November 2007*)

544 **Jarlan**, **L.**, **G. Balsamo**, **S. Lafont**, **A. Beljaars**, **J.C. Calvet**, **E. Mougin**: Analysis of Leaf Area Index in the ECMWF land surface scheme and impact on latent heat and carbon fluxes. Application to West Africa. (*November 2007*)

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- **Workshop on Parametrization of clouds in large-scale models**, 13–15 November 2006

EUMETSAT/ECMWF Report Series

Final Report SOW EUM.MET.SOW.04.0290 **Kelly**, **G.** and **J.-N. Thépaut**: Evaluation of the impact of the space component of the Global Observing System through Observing System Experiments. *October 2007*

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Project Acronym	Project Name	ECMWF role	Date		Funded by	ECMWF budget (€)	Total budget (€)
			From	To			
ADM/AEOLUS	Development and production of aeolus wind data products	Subcontractor	01/10/04	31/01/08	ESA	1,026,923	n/a
AGCC	Observation Techniques and Mission Concepts for Analysis of the Global Carbon Cycle	Subcontractor	06/09/07	31/08/09	ESA	21,250	500,000
AMMA	African Monsoon Multidisciplinary Analysis	Contractor	01/01/05	31/12/08	EC	372,780	11,700,000
ARM	Model validation studies	Contractor	15/04/07	14/04/10	US DoE	$366,496	n/a
BOSS4GMES	Building Operational Sustainable Services for GEMS	Contractor	01/12/06	01/06/09	EC	149,997	11,800,000
BRIDGE	Bilateral Research and Industrial Development Enhancing and Integrating GRID Enabled Technologies	Subcontractor	01/01/07	31/12/08	EC	250,724	1,700,000
DEISA	Distributed European infrastructure for supercomputing applications	Contractor	01/05/04	30/04/08	EC	709,800	14,000,000
EC-EARTH	EC-EARTH	Contractor	11/10/07	10/10/09	KNMI	256,000	n/a
eDEISA	Extended distributed European infrastructure for supercomputing applications	Contractor	01/06/06	31/05/08	EC	131,200	4,500,000
ENSEMBLES	Ensemble-based predictions of climate change and their impacts	Contractor	01/09/04	31/08/09	EC	1,124,475	15,000,000
ENVISAT II	Technical support for global validation of ENVISAT data products	Contractor	01/01/06	31/12/07	ESA	327,000	480,000
EPS/IASI	Support of ECMWF to EPS/IASI phase 3	Contractor	01/01/06	31/12/07	EUMETSAT	262,939	262,939
ERA	ERA	Subcontractor	01/09/207	31/08/10	NCAS	£166,000	n/a
ERS Validation II	Technical support for global validation of wind and wave products (ERS II)	Contractor	01/04/04	30/06/08	ESA	499,000	499,000
EUMETSAT fellowships	Fellowships	Contractor	Ongoing		EUMETSAT	n/a	n/a
EURORISK PREVIEW	Prevention, information and early warning pre-operational services to support the management of risks	Contractor	01/04/05	31/12/08	EC	215,000	14,300,000
FREEVAL	Evaulation of a Fire Radiactive Power Product derived from Meteosat 8/9 and Identification of Operational User Needs	Subcontractor	01/12/06	31/10/07	EUMETSAT	14,419	123,573
GEMS	Monitoring using satellite and in-situ data	Co-ordinator	01/03/05	28/02/09	EC	4,691,000	12,500,000
GEOLAND	GMES products & services, integrating EO monitoring capacities to support the implementation of European directives & policies related to "land cover & vegetation"	Contractor	01/01/04	31/03/07	EC	450,000	10,000,000
GEOMON	Prototype system for atmospheric composition monitoring for climate applications by the combination of ground-based with satellite observations	Subcontractor	01/02/07	31/01/09	EC	28,800	6,621,740
GlobeMODEL	GlobeMODEL	Subcontractor	01/01/07	31/05/08	ESA	24,668	249,689
GRAS-SAF	The continuous development and operations phase of a EUMETSAT satellite applications facility on GRAS meteorology	Subcontractor	01/03/07	29/02/12	EUMETSAT	610,000	4,200,000
HALO	Harmonised coordination of the atmosphere, land and ocean, integrated projects of the GEMS backbone	Co-ordinator	01/02/04	30/04/07	EC	404,000	900,000
H-SAF	Satellite Application Facility on support to operational hydrology and water management	Contractor	01/09/05	31/08/10	EUMETSAT	220,000	3,000,000
JRC HPC facilities	Provision of flexible dedicated High Performance Computing facilities	Contractor	01/08/06	31/03/09	JRC	433,182	433,182
MERSEA	Marine Environment and Security for the European Area	Contractor	01/04/04	30/09/07	EC	326,400	24,400,000
NWP SAF	Development & Implementation of certain activities within a EUMETSAT satellite application facility on numerical weather prediction	Subcontractor	01/03/04	28/02/12	EUMETSAT	1,574,721	7,400,000
OSE EUCOS	Observation System Experiment	Subcontractor	03/05/05	31/07/07	EUCOS	59,000	n/a
OSE EUMETSAT	Observation System Experiment	Contractor	01/08/05	31/07/07	EUMETSAT	236,000	236,000
Post-EPS	Optimisation of the Oxygen and Water Vapour Sounding Channels	Contractor	06/06/07	30/09/08	ESA	140,348	249,961
SIMDAT	Data grids for process and products development using numerical simulation and knowledge discovery	Contractor	01/09/04	31/08/08	EC	819,000	11,000,000
SMOS DA	Study methods and techniques to best assimilate SMOS data into ECMWF's operational numerical weather forecasting system	Contractor	02/02/07	30/04/09	ESA	299,136	299,136
UKMO-EPS	Maintenance of software to implement ensemble seasonal predictions using various configurations of the Met Office Unified Model	Contractor	01/08/05	31/07/08	UK Met Office	n/a	n/a

Glossary

ACMAD	African Centre of Meteorological Applications for Development
ADPC	Asian Disaster Preparedness Center
AIRS	Atmospheric InfraRed Sounder
AMSR-E	Advanced Microwave Scanning Radiometer-E
AMSU-A	Advanced Microwave Sounding Unit-A
ASCAT	Advanced Scatterometer
BOM	Bureau of Meteorology (Australia)
CERES	Clouds and the Earth's Radiant Energy System
CERFACS	European Centre for Research and Advanced Training in Scientific Computation
cpu	central processing unit
CFAB	Climate Forecasting Application to Bangladesh
CLRTAP	Executive Body of the Convention on Long-range Transboundary Air Pollution
CMA	Chinese Meteorological Administration
COST	European Co-operation in the Field of Scientific and Technical Research
CTBTO	Preparatory Commission for the Comprehensive Nuclear Test-Ban Treaty Organization
DHS	Data Handling System
DWD	Deutscher Wetterdienst (German National Meteorological Service
EC	European Commission
ECFS	ECMWF Common File System
ECMWF	European Centre for Medium-Range Weather Forecasts
EFAS	European Flood Alert System
EFI	Extreme Forecast Index
ENVISAT	Environmental Satellite
EOS	Earth Observing Systems
EPS	Ensemble Prediction System
EPSgram	EPS Meteogram
ERA-15	ECMWF Reanalysis, 1979–1993
ERA-40	ECMWF Reanalysis, 1957–2002
ESA	European Space Agency
EU	European Union
EUCOS	EUMETNET Composite Observing System
EUMETCAL	European Meteorological Computer Assisted Learning
EUMETNET	European Meteorological Network
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
FREEVAL	Fire Radiative Energy Validation
GCOS	Global Climate Observing System
GEO	Group on Earth Observation
GEMS	Global Environment Monitoring System
GEOSS	Global Earth Observation System of Systems
GMES	Global Monitoring for the Environment and Security initiative
GOS	Global Observing System
GPSRO	GPS radio occultation
GTS	Global Telecommunication System
HIRS	High Resolution Infra Red Radiation Sounder
HPC	High Performance Computing
hPa	hectoPascal
HPCF	High Performance Computing Facility
IASI	Infrared Atmospheric Sounding Interferometer
IFS	Integrated Forecast System
I/O	input / output
IPVPN	Internet Protocol Virtual Private Network
JMA	Japanese Meteorological Administration
JRC	Joint Research Centre of the European Commission
KMA	Korean Meteorological Administration
KNMI	Royal Dutch Meteorological Institute
MACC	Monitoring Atmospheric Composition and Climate
MAGICS	Meteorological Application Graphics Integrated Colour System
MARS	Meteorological Archival and Retrieval System
MetOp	Meteorological operational satellite (polar-orbiting)
MHS	Microwave Humidity Sounder
MODIS	Moderate Resolution Imaging Spectroradiometer
MPLS	Multi Protocol Label Switching
MSC	Meteorological Service of Canada
NASA	National Aeronautics and Space Administration (USA)
NCAS	National Centre for Atmospheric Science
NCEP	National Centers for Environmental Prediction (USA)
NWP	Numerical Weather Prediction
OMI	Ozone Monitoring Instrument
OSE	Observing System Experiments
PREVIEW	Prevention Information and Early Warning
RMDCN	Regional Meteorological Data Communications Network
SBUV	Solar Backscatter UltraViolet
SIMDAT	Data Grids for Process and Product Development using Numerical Simulation and Knowledge Discovery
SSMIS	Special Sensor Microwave Imager/Sounder
THORPEX	The Observing System Research and Predictability Eperiment
TIGGE	THORPEX Interactive Grand Global Ensemble
TMI	TRMM (Tropical Rainfall Measuring Mission) Microwave Imager
UNOSAT	UNITAR (UN Institute for Training and Research) Operational Satellite Applications Programme
UTC	Universal Time Constant
VarEPS	Variable Resolution Ensemble Prediction System
VGISC	Virtual Global Information System Centre
WCRP	World Climate Research Programme
WIS	WMO Information System
WMO	World Meteorological Organization
WWRP	World Weather Research Programme

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