

European Centre for Medium-Range Weather Forecasts

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ECMWF is the world leader in medium-range weather forecasting. Professor Alan Thorpe, Director-General for the Centre explains the organisation's coordination efforts and technology required to provide round-the-clock state-of-the-art forecasting services to users worldwide.



First, can you briefly outline the context from which the European Centre for Medium-Range Weather Forecasts (ECMWF) emerged in 1975?

In the late 1960s, a number of European scientists had the vision that forecasting the weather up to 10 days ahead would be possible. Such medium-range weather forecasts would be of enormous benefit for the protection, safety and economic development of society. As a result, European governments agreed to combine their individual resources and establish an intergovernmental organisation with the goal of developing, improving and operationally producing medium-range weather forecasts.

Today, ECMWF is an intergovernmental organisation supported by 34 countries in and around Europe. It was established in 1975 to pool together resources in Europe to provide high quality weather forecasts for the benefit of European citizens. Since then it has become the world leader in global numerical weather prediction.

What are ECMWF's objectives?

ECMWF's objectives are to operationally predict the weather up to 15 days ahead as well as to continuously improve the numerical forecasting models through research and development activities. The science of numerical weather modelling is to find the best way of representing the highly complex processes in our Earth System in a computationally efficient manner. ECMWF's numerical model system is acknowledged for producing the best numerical weather predictions worldwide.

One of the Centre's main tools is the Integrated Forecasting System (IFS). Can you explain the function of this system?

The comprehensive Earth System model developed at ECMWF forms the basis for all the data assimilation and forecasting activities. All the main applications required are available through a single computer software system called the IFS.

The development of a reliable severe weather forecasting system, extending well out into the medium-range and beyond, will be achieved within the context of an improved ensemble prediction system which forecasts case- and site-specific prediction uncertainty.

An ensemble forecast works by running not just one weather forecast every day, but a large number. In fact, the Centre runs 51 forecasts every 12 hours. This allows weather forecasters to get some indication of whether they can be confident of the forecast or whether a forecast is uncertain.

ECMWF is one of the few centres worldwide to produce forecasts on a time scale even further ahead than 15 days. These monthly and seasonal predictions cannot be used to predict, for instance, whether it will rain in Paris on the last day of next month, but they can indicate how likely it is that next month or season will be warmer or wetter than it usually is. Such information can be of vital importance in the area of health protection, such as malaria early warning systems in Africa.

What is the principal goal of ECMWF for the forthcoming decade?

In June 2011, the ECMWF Member States unanimously adopted the Centre's Strategy for the period 2011 to 2020. The vision of this Strategy is for ECMWF to be the acknowledged world leader in global, medium-range numerical weather prediction. This means providing the best possible forecast products to our Member States, particularly to European national weather services, for the benefit of society.

The aims are that by 2020:

- Reliable early warnings for severe weather will be routinely received and acted upon by European citizens
- Many national weather services will deliver tailored medium-range forecasts using direct ECMWF model output
- We will deliver operationally global analyses and forecasts of atmospheric composition
- We will continue to support climate monitoring with state-of-the-art reanalyses of the Earth System.

How important is medium-range forecasting? What services does the Centre offer and who are the end-users?

ECMWF's numerical weather predictions are one of the most important sources of information for meteorologists in weather services. These meteorologists then produce weather forecasts tailored for different customers, such as emergency services, transport, the media and the general public.

Economies are becoming increasingly sensitive to weather impacts and the management of resources relies heavily on weather forecasts, with financial consequences several orders of magnitude above the cost of the meteorological infrastructure.

Who benefits from our weather forecasts and products? Directly: National Hydro-Meteorological Services, meteorological service providers and scientists, for instance those monitoring the environment and climate change. Indirectly: Military and civil defence authorities, local authorities and emergency services, the general public, national health services, energy providers, and the offshore oil and gas industry, shipping, commercial fishing and coastal protection agencies, weather-sensitive manufacturing, all forms of transport, as well as European Union, national and regional policy makers.

ECMWF has demonstrated a much improved capability for providing good medium-range forecasts of severe weather events in recent years, such as in 2010, summer droughts and wildfires in Russia, winter storm Xynthia, and exceptional rainfall in Pakistan.

The Centre runs a wide-ranging programme of research and development directed at improving the quality and variety of forecast products for the medium-range and beyond. What are the most crucial research areas the programme is currently addressing?

Approximately 100 staff and consultants work in the Research Department on all aspects of the forecast and data assimilation systems. The result of this research effort is one of the most comprehensive Earth System models available anywhere.

For ECMWF to remain the world leading centre for global medium-range weather prediction, an ambitious and forward-looking scientific and technical vision is required. The success of ECMWF depends crucially on its ability to develop and implement innovative techniques in numerical weather prediction. The research programme will continue to be at the international forefront of developments in this area of science and it will be supported by a leading-edge computing facility.

ECMWF's research strategy focuses on higher spatial resolution because this both improves numerical accuracy and the assimilation of observations as well as defining with greater fidelity the critical extreme weather events. In the medium-range, and for near-surface forecasting, improved coupling of the atmosphere to the underlying surface - land and ocean - is important and also critical for forecast lead times extending out to monthly and seasonal timescales.

Development and exploitation of advanced ensemble data assimilation techniques with large ensemble sizes and high resolution is seen as a way to extend the period of reliable predictions as well as providing better probabilistic estimates of the likelihood of extreme weather. Exploiting observations of parameters related to atmospheric composition will not only allow prediction of high-impact pollution events but may also benefit medium-range weather forecasts.

How does the work of ECMWF benefit EU citizens?

ECMWF has proven to be a unique and successful European organisation. Over the years, it has provided both its Member and Cooperating States with numerical weather forecasts of the highest quality. Those who benefit most are the European citizens since they have access to the best forecasting system worldwide.

ECMWF leads the world in global medium-range numerical weather prediction, the advanced computer observation-analysis modelling technique used to predict the weather. Our operational activities and wide-ranging programmes of research and development have played a pioneering role in the remarkable advancement of data assimilation and weather prediction systems.

Monitoring Atmospheric Composition and Climate (MACC) - is the current pre-operational atmospheric service of the European GMES programme, funded under the EU's Seventh Framework Programme. MACC provides data records on atmospheric composition for recent years, data for monitoring present conditions and forecasts of the distribution

of key constituents for a few days ahead. MACC combines state-of-the-art atmospheric modelling with Earth Observation data to provide information services covering European Air Quality, Global Atmospheric Composition, Climate, and UV and Solar Energy.

ECMWF has steadily increased its forecasting capabilities by improving the existing systems and by creating new capabilities, such as ensemble forecasting, ocean-wave forecasting, seasonal forecasting, monthly forecasting, and - most recently - atmospheric composition forecasting.

Such highly skilful weather forecasts are vital for society. Citizens are increasingly vulnerable to extreme events that are weather-related such as flooding, wind-storms and poor air quality. Forecasts enable mitigating actions to be taken in order to minimise detrimental consequences of severe weather. They also enable new business opportunities to flourish which exploit this knowledge about the natural environment and how it will develop.

The Centre runs two independent supercomputer systems. What benefits are derived from this cutting-edge technology?

As the world's leading centre on global medium-range numerical weather prediction, our reputation rests on our ability to deliver a consistent and reliable service 24 hours a day, 7 days a week. At the core of our operational and research activities lies one of the largest computing centres in Europe. We have operated a High Performance Computing Facility for weather prediction since the installation of our first supercomputer in 1978.

Our extremely powerful supercomputers enable us to:

- Collect and check approximately 550 million observations daily and actively assimilate some 35 million a day into the numerical models
- Produce global numerical predictions
- Perform research experiments to advance numerical weather prediction techniques and products
- Provide Member States with invaluable resources for their own research into numerical weather prediction

Our computer and ancillary facilities, such as data handling and networking, are regularly upgraded to accommodate the greater computational power demanded by the assimilation of even more observational data and the ongoing evolution of our forecasting models.



The massive amount of data required for and generated by weather forecasting is archived in our Data Handling System. Since 1975, ECMWF has built up a unique archive of meteorological data for use by researchers as well as for educational and commercial purposes. As of 2011, this archive holds more than 20 petabytes of data.

ECMWF has an extensive education and training programme to assist Member States and Cooperating States in the training of scientists in numerical weather forecasting, and in making use of the ECMWF computer facilities. Can you highlight some of these activities and explain how researchers can become involved in these programmes?

Education and training is very important. Sophisticated models and techniques require targeted information, and ECMWF offers a broad range of educational activities and training courses. ECMWF has an extensive education and training programme to assist Member States and Cooperating States in the training of scientists in numerical weather forecasting, and in making use of the ECMWF computer facilities. Topics of training courses comprise:

- Use of Computing Facilities. An introduction to the use of ECMWF computing and archive facilities
- Use and interpretation of ECMWF Products. Introducing ECMWF products in operational weather forecasting available to the Member States
- Numerical weather prediction. A course which targets the various aspects of research on numerical weather prediction at ECMWF, and consisting of four modules covering scientific training on numerics, physics, data assimilation and predictability

The Centre also fosters scientific exchange with the wider research community. Many ideas for improving the model systems have been conceived during scientific seminars and workshops organised by ECMWF.



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ECMWF is an intergovernmental organisation supported by more than 30 States. It provides weather services with medium-range forecasts of global weather to 15 days ahead as well as with monthly and seasonal forecasts. ECMWF's computer system at its headquarters in Reading, United Kingdom, is one of the largest for meteorology worldwide and contains the world's largest archive of numerical weather prediction data. It runs a sophisticated medium-range prediction model of the global atmosphere and oceans. 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.

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