

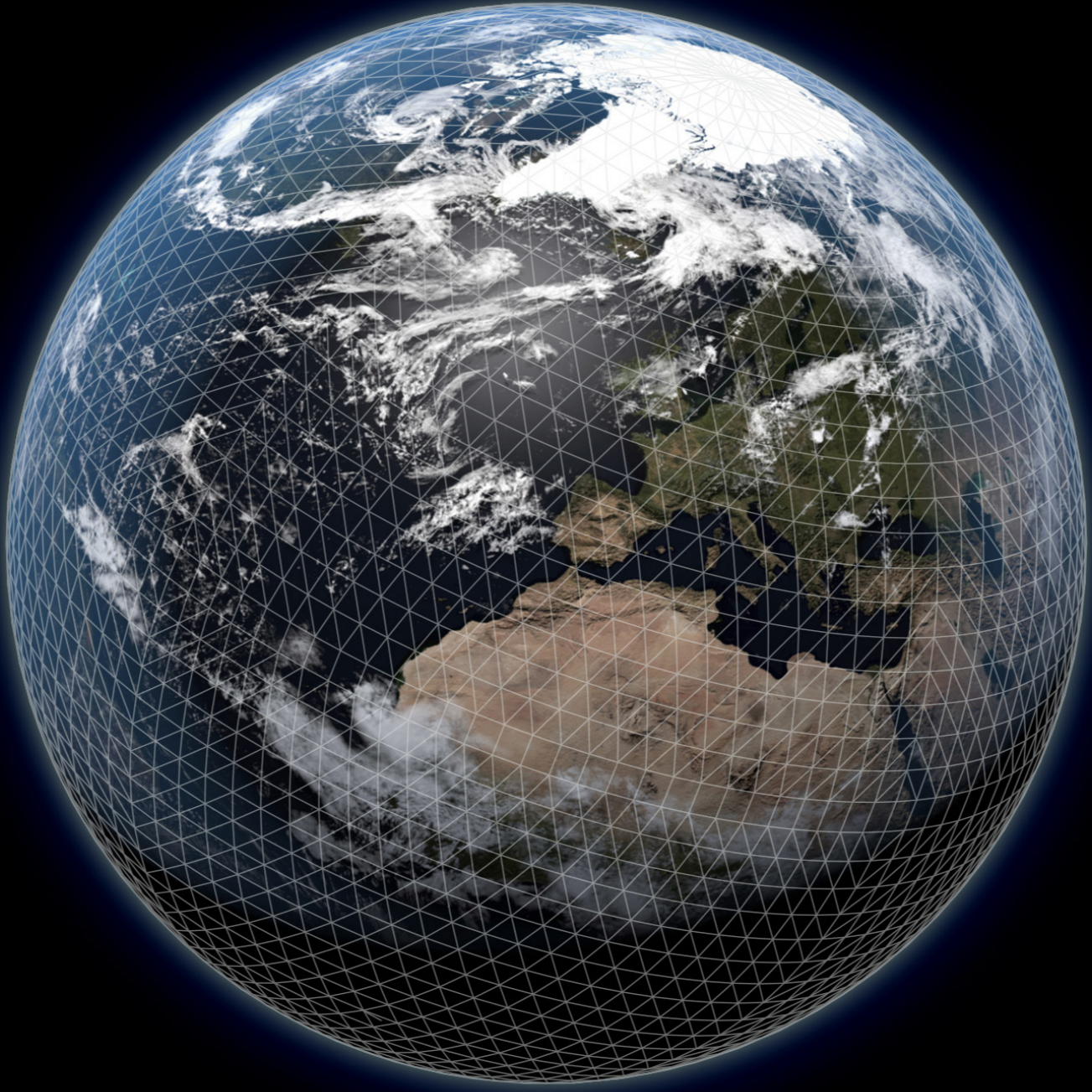


### Building effective partnerships

Since its creation in 1975, ECMWF has benefited from the support of its growing number of Member and Co-operating States: support in funding as well as in scientific cooperation and expertise sharing. ECMWF has also expanded its collaborative approach through different types of partnerships with meteorological services, research centres, universities and space agencies in Europe, the USA, China, Brazil and Japan, and of course through the World Meteorological Organization (WMO). Though independent from it, ECMWF also has a strong partnership with the EU. Research grants from the EU have allowed the Centre to advance its expertise in the areas of scalability and seasonal forecasting, among others. ECMWF operates two services of the EU flagship Copernicus programme, for climate change and atmospheric monitoring, and it is part of the EU's Destination Earth initiative to create a digital twin of Earth.



Reading, UK; Bologna, Italy; Bonn, Germany  
[www.ecmwf.int](http://www.ecmwf.int)



## ADVANCING WEATHER SCIENCE TO IMPROVE GLOBAL NUMERICAL WEATHER PREDICTION

ECMWF is an intergovernmental organisation established on 1 November 1975 with the core mission to advance weather science to improve numerical weather prediction. The Centre has 23 Member States and 12 Co-operating States and employs over 450 international staff across three duty stations. It is both a research institute and a 24/7 operational service, producing global numerical weather predictions and other data for its Member and Co-operating States and the broader community. The Centre also offers a catalogue of forecast data available under various types of licences, including commercial licences, and a growing range of open data and charts. Other strategic activities include maintaining a data archive, delivering advanced training, and assisting the World Meteorological Organization (WMO) in implementing its programmes.

ECMWF also contributes to the delivery of environmental information on behalf of the European Union (EU) through its involvement in the Copernicus Programme. This includes climate, atmospheric composition, fire danger, and flood information. Through the EU Destination Earth initiative, which is being jointly developed by ESA, EUMETSAT and ECMWF under the auspices of the European Commission, ECMWF is creating digital twins of the Earth system, supporting climate change adaptation policies and decision-making for reducing the impacts of extremes.

EUROPEAN CENTRE FOR MEDIUM-RANGE WEATHER FORECASTS



**ECMWF was established as a major initiative in European scientific and technical cooperation in meteorology, based on a high-performance computing facility, a scientific and technical workforce, the production of medium-range weather forecasts, and related research and development. The collaborative approach of ECMWF remains to this date a key to its success and is helping the Centre to continue to develop its models and satisfy its users' evolving requirements.**

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## **Global numerical weather prediction at ECMWF**

### **An Integrated Forecasting System**

ECMWF's Integrated Forecasting System (IFS) produces forecasts for multiple time ranges to address different user requirements. These provide key aspects of the forecast evolution and the associated uncertainty. Specific products are designed to highlight potential severe weather events, including, for instance, tropical cyclones and heatwaves.

Predictions cover the medium range (up to 15 days ahead), extended range (up to 46 days ahead), and long range (up to a year ahead).

### **Ensemble forecasts**

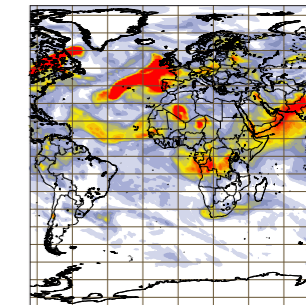
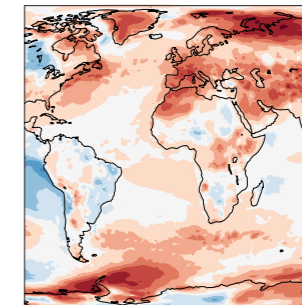
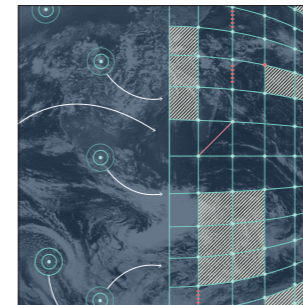
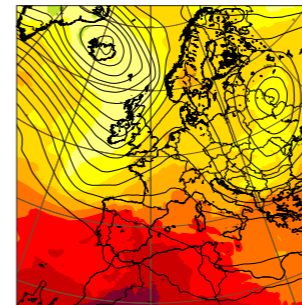
Each ECMWF medium-range forecast is made of 51 ensemble members at 9 km horizontal resolution covering a range of up to 15 days.

Extended-range weather predictions up to 46 days ahead are based on 101 ensemble members. They show predicted week-to-week changes in the weather.

Long-range predictions, also called seasonal forecasts, are mainly issued up to seven months ahead. They are ensemble forecasts too, and they provide expected future atmospheric, land, and oceanic conditions averaged over one to three months. ECMWF's long-range predictions also feed into the seasonal forecast pages of the EU's Copernicus Climate Change Service (C3S) implemented by ECMWF. These pages show seasonal forecasts for a range of parameters from eight forecasting centres, including ECMWF, and combined C3S multi-system seasonal charts.

### **Assessing the uncertainty**

Ensemble-based weather predictions describe the range of possible scenarios and their likelihood of occurrence. They enable and support informed planning and decision-making for policy-makers and emergency services as well as the commercial sector and citizens.



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## **Shaping the future of supercomputing in numerical weather prediction**

ECMWF has operated a world-class high-performance computing (HPC) facility for weather forecasting since the installation of its first CRAY-1 supercomputer in 1978. The current system comprises four Atos BullSequana XH2000 clusters and is housed in ECMWF's data centre in Bologna, Italy.

The available computing resources are allocated to operational activities (25%), ECMWF's research programme (50%) and workload from ECMWF's Member States (25%). Emphasis is placed on delivering the operational forecast production to a strict schedule, providing a good service to users, whilst using the HPC resources effectively and maintaining a very high level of utilisation.

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## **Exploring machine learning in numerical weather prediction**

As data volumes grow and the demands for energy-efficient computing become ever greater, machine learning (ML) has a key role to play in numerical weather prediction (NWP), and in Earth system modelling and prediction more generally. Recognising the opportunities but also the challenges involved, ECMWF is intensifying its development in this field in collaboration with its Member States.

