ECMWF

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 11 Co-operating States. 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. 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 through its involvement in the Copernicus Programme. This includes climate, atmospheric composition, flood, and fire danger information.

EUROPEAN CENTRE FOR MEDIUM-RANGE WEATHER FORECASTS

ECMWF was established as a major initiative in European scientific and technical co-operation 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 aspect 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.

Global numerical weather prediction at ECMWF

An Integrated Forecasting System

Our 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.

Our predictions cover the medium range, up to two weeks ahead, extended range, up to a month ahead, and long range, up to a year ahead.

An ensemble of 52 members

Each ECMWF forecast is made of one member (HRES) at 9 km horizontal resolution and 51 other members at 18 km horizontal resolution

These are separate forecasts made by the same computer model, all activated from the same starting time. The starting conditions for each member of the ensemble are slightly different, and physical parameter values used also differ slightly. The differences between these ensemble members tend to grow as the forecasts progress, which is as the forecast lead time increases.

Assessing the uncertainty

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

Accurate forecasts

The skill of the HRES member has been advancing at approximately one day per decade, whilst the ensemble's skill has improved by one and a half day per decade.

NWP: an initial conditions challenge

ECMWF routinely processes data from over 90 satellite instruments as part of its operational daily data assimilation and monitoring activities. Each day, 70 million quality-controlled observations are available for assimilation by the IFS; the vast majority of these are satellite measurements, but ECMWF also benefits from all available observations from non-satellite sources, including surface-based and aircraft reports.

Until recently the main impact arose from microwave and hyperspectral infrared temperature sounders, from winds observations derived from scatterometers and by tracking features in sequences of images (so called atmospheric motion vectors) as well as from conventional observations (e.g. radiosondes). Now, after years of research conducted at ECMWF, data from microwave humidity sounders and imagers is assimilated in all-sky conditions over the ocean, land and sea-ice. As a result, microwave humidity observations are now also having a very significant impact on medium-range forecast scores, up to the same level as the temperature observations.

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. ECMWF's HPC has always been amongst the most powerful supercomputers in Europe and provides users with leading-edge HPC technologies. The current system, made up of two Cray XC40 clusters, will be replaced by four Atos Sequana XH2000 clusters to be operational early 2022.

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.

ECMWF's new data centre in Bologna, Italy, is set to open in 2021, and become fully operational in early 2022.

Scalability

Forecasting models represent processes acting on a wide range of scales, becoming finer and finer in the atmosphere, the ocean, the land surface and the cryosphere. Meeting society's need for improved forecasts delivered in a timely manner will require an increase in high-performance computing and data management resources by a factor of 100 to 1,000 – towards what is generally called the 'exascale'. To make this possible, weather and climate prediction is undergoing one of its biggest revolutions since its beginnings in the early 20th century. This revolution encompasses a fundamental redesign of mathematical algorithms and numerical methods, the adaptation to new programming models, the implementation of dynamic and resilient workflows and the efficient post-processing and handling of big data.

With a holistic view on this challenge, ECMWF launched its Scalability Programme in 2013 with strong support from its Member States. Projects initiated as part of the programme cover all current forecasting system steps, from observational data pre-processing, data assimilation and modelling to model output data post-processing and key code developments in view of existing and future computer architectures.

Copernicus: the European programme for monitoring the earth

Copernicus, the EU's Earth Observation Programme, ensures the regular observation and monitoring of Earth sub-systems, namely the atmosphere, oceans, and land surfaces. Through a combination of state-of-the-art satellites, contributing missions, in-situ data and services, Copernicus provides timely, reliable, and validated information in support of a broad range of environmental, climate and security policies and applications.

ECMWF has been entrusted by the EU to operate the Copernicus Atmosphere Monitoring Service (CAMS) and Climate Change Service (C3S). ECMWF is also involved in the Emergency Management Service through its contribution to the European and Global Flood Awareness Systems (EFAS and GloFAS) and the European Forest Fire Information System (EFFIS).
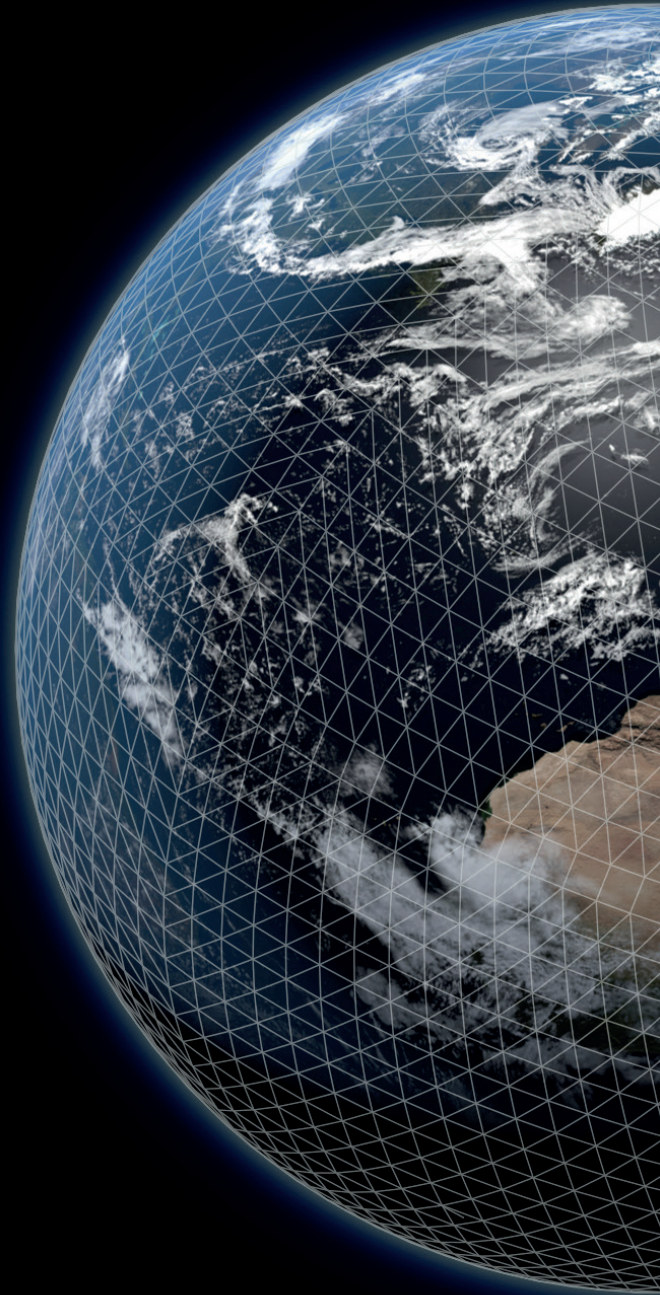
Building effective partnerships

Over the past 45 years, 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 cooperation with meteorological services, research centres, universities and space agencies across the USA, China, Brazil, 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. In 2014, ECMWF became the operator of two services of the EU-flagship Copernicus Programme, for climate change and atmospheric monitoring.

⊂⊃ ECMWF

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