Met Office

Clarity

Helping you understand the facts about weather forecasting

Forecasting the weather

is essential to help you prepare for the best and the worst of our climate.

Met Office forecasters work 24/7, 365 days of the year, using one of the world's largest supercomputers to predict the weather for hours, days, weeks, seasons and even years ahead.

Operating as part of an international network to collect weather data, we also partner with research institutes worldwide to develop the very latest techniques. We strive to ensure that you always have the very best advice in print, on air, and via the web.

Our forecasts for tomorrow are right six times out of seven. Here you will find some facts about weather forecasting – an insight into our foresight.

Observations are essential

FACT 1 — Before we forecast the weather, we collect observations.

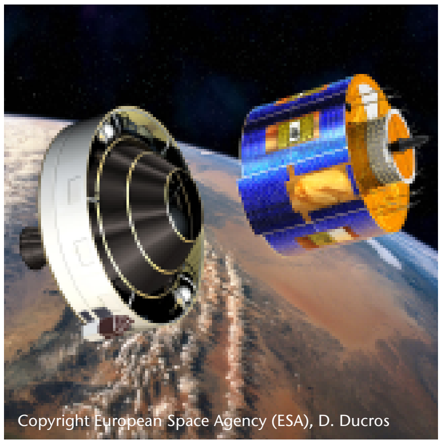
Observations
Observations of the weather are made 24 hours a day, all over the world. The main observations are from weather satellites, balloons, land-based instruments, ships, buoys and aircraft.

Each day, the Met Office uses around half a million observations of temperature, pressure, wind speed and direction, humidity and many other properties to provide the starting conditions of our weather forecast model. We continually update our knowledge of the current state of the atmosphere.

- Satellites measure radiation from Earth's surface and the atmosphere.
- Balloons and aircraft measure the bit of the atmosphere that they are passing through.
- Buoys and land stations measure the lower part of the atmosphere.
- Radar systems measure the reflection of radiation from rain drops and snowflakes.

Assimilation
Next we turn observational data into a numerical representation of the current atmospheric conditions. This process is known as assimilation.

Small changes in atmospheric conditions lead to very different weather patterns, so it's vital that the current state of the atmosphere is represented as accurately as possible.



We use numerical models and supercomputers

FACT 2 — We use numerical computer models and supercomputers to forecast the weather.

Numerical Weather Prediction (NWP)
We predict how atmospheric conditions will change with our knowledge of the atmosphere, oceans and land surface.

Our numerical model starts with the current atmospheric conditions in the area of interest from the surface to the upper atmosphere at points on a three-dimensional grid.

The atmosphere is a thin shell of turbulent gas on a rotating Earth. Numerical Weather Prediction (NWP) models replicate the behaviour of this gas with mathematical equations.

Details of the wind speed and direction, temperature, pressure, moisture and cloud in each grid box are then stored in a computer.

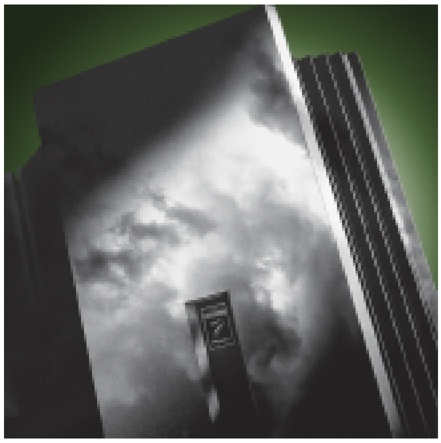
Equations describing all of the relevant atmospheric processes are solved for each grid box to predict the values at that point several minutes later.

Met Office research scientists work to improve understanding of atmospheric processes, so they can be better simulated in our forecast model, and ultimately, lead to more accurate forecasts.

This is done by a combination of making and studying new types of observations and advanced numerical simulations.

The Met Office model is called the Unified Model (UM) as different configurations of the same model are used for both weather and climate prediction.

Supercomputers
Numerical weather prediction involves billions of mathematical calculations. The process of turning observational data into a numerical representation of the atmosphere takes the supercomputer longer than it does to actually make the forecast. We use powerful supercomputers to do these calculations as quickly as possible.



Human intervention is key

FACT 3 — Human forecasters check and improve our forecasts.

Our expert forecasters use their knowledge to compare the predictions of computer models against actual observations. If necessary, they can respond quickly and amend a computer forecast if it is going wrong in some way – for example, computer models sometimes have problems forecasting thunderstorms and other small-scale details a short period ahead. In such a situation, rainfall radar observations and satellite pictures can be very useful when making predictions over short periods of time. This is an example of forecasters adding value to computer guidance.

Another example of forecasters adding value to computer guidance is by correcting for known biases or weaknesses in computer model predictions. Through skilful interpretation of computer output, forecasters also decide on the correct emphasis in weather forecasts. Forecasters also tailor forecast information to the interests of different customer groups which can include for example, the general public, emergency responders or airlines.

Sifting through the vast quantities of forecast data from the NWP system and identifying which are of particular significance to particular customers on a particular day is a risk assessment process, considering the vulnerability of each user to all aspects of the weather.

To ensure that people and critical operations will not be put at risk by unexpected weather, the Met Office Operations Centre operates round the clock throughout the year, even on Christmas Day.

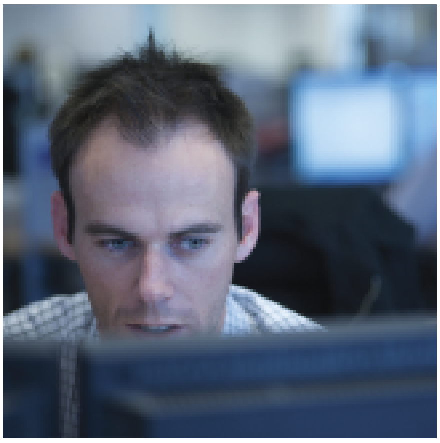
Nowcasting

Nowcasting is a technique for very short-range forecasting that maps the current weather, and then uses an estimate of its speed and direction of movement to forecast the weather a short period ahead – assuming the weather will move without significant changes.

The Met Office uses nowcasting for many weather variables including wind, temperature, snow and fog.

As a forecasting technique it can be applied quickly, either by human forecasters or by modest-sized computers, so it is possible to update the forecasts frequently – every time there are new observations available.

Most Met Office nowcasts are updated every hour.



We use a variety of techniques

FACT 4 — To produce weather forecasts for one to 15 days ahead, we use a variety of techniques.

Ensemble forecasting
One example of the range of techniques we use to forecast the weather is ensemble forecasting. The risk of particular weather events can be estimated using ensemble forecasting.

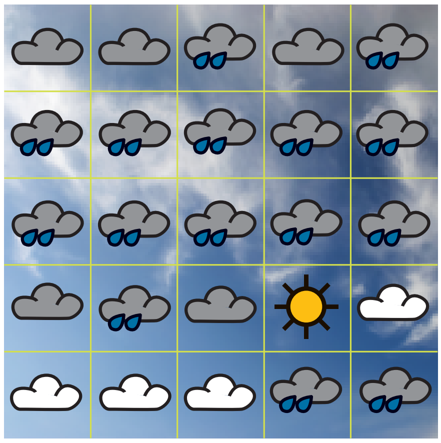
An ensemble forecasting system samples the uncertainty inherent in weather prediction to provide more information about possible future weather conditions. Multiple forecasts are produced by making small alterations to either the starting conditions or the forecast model, or both.

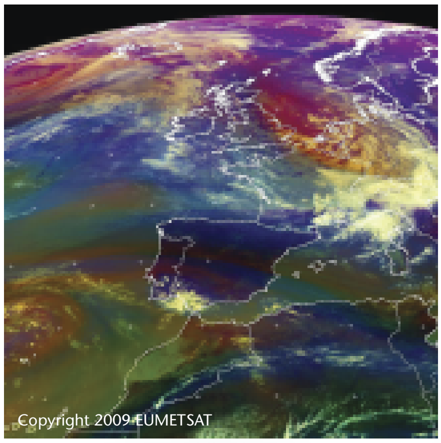
Weather happening many thousands of miles away today will affect the weather over the UK in a few days time. In medium-range forecasts of two to 15 days ahead, the use of ensemble forecasting is essential as the uncertainty in the large-scale weather patterns becomes greater.

Probability and decision-making
By assessing the uncertainty in a forecast, ensemble forecasting helps decision-makers judge the appropriate level of response to a risk of high-impact weather.

When the predicted risk of a severe weather event is high it can give forecasters the confidence to issue earlier warnings. If there is a smaller probability of a severe event then emergency planners and vulnerable businesses can still be alerted to protect their vulnerable assets via a special advisory service.

The output from the ensemble systems allows the uncertainty of the forecast to be quantified, and the risk of a particular weather event occurring can be assessed. This can aid decision-making for those who are at risk from certain weather events.





We are always improving our forecasts

FACT 5 — We are always improving our forecasts.

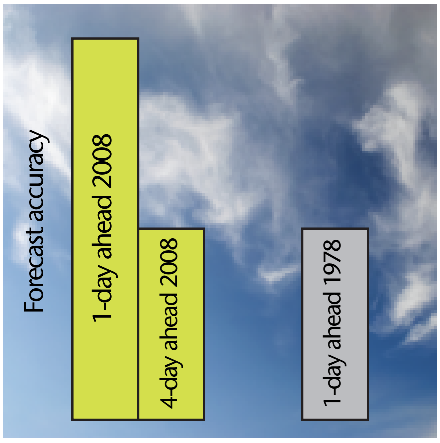
We measure the accuracy of all our forecasts. Over the years, there has been a steady pattern of improvement. For example, our four-day forecasts are now as accurate as our one-day forecasts were 30 years ago.

Improvement in forecast accuracy is a result of investment in research, faster supercomputers and greater coverage and the targeting of observations.

There are a number of ways of measuring the accuracy of a forecast. One method used at the Met Office is called the Numerical Weather Prediction (NWP) index. This combines the accuracy of a number of different elements into a single measure of overall accuracy.

Another way of monitoring the accuracy of our forecasts is by setting targets for:

- Next-day rainfall forecasts for 11 places within the UK.
- Next-day temperature forecasts (max and min) for 11 places within the UK.
- The overall forecasting skill of our computer models assessed by the NWP Index that takes into account computer forecasts for several weather elements which we can compare with other forecasting centres around the world.



The atmosphere is chaotic

FACT 6 — The atmosphere is chaotic.

Despite the expertise of our researchers and forecasters, and the sophistication of our computers and satellites, our forecasts are sometimes inaccurate. This is due to the complexity of the atmosphere and a lack of observational data. In fact, the atmosphere is a chaotic system:

- The atmosphere is often in a state where small disturbances reinforce themselves, systems such as thunderstorms or depressions.
- Small initial state uncertainties or model errors may rapidly lead to large forecast errors.
- Such states mostly arise from uneven heating, for example the equator to pole variation in solar intensity; land / sea differences in absorption of solar radiation; variations in land use, cloud cover, melting and evaporation.

To further improve the accuracy of our forecasts we are investing in further research to reduce the likelihood of errors. In addition to improving the accuracy of the one- to five-day forecast, research has enabled us to make forecasts that were previously impossible.

We can now forecast further into the future allowing regular seasonal forecasts to be produced, and predictions of climate change are continually improving.

New research is expected to provide further significant improvements in our ability to forecast heavy thunderstorms a few hours in advance.

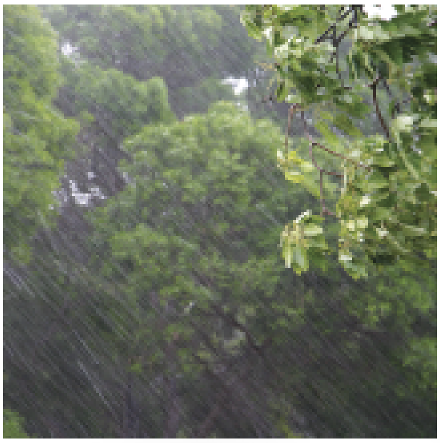
Size matters – small is less predictable

FACT 7 — Size matters – small is less predictable.

There are many different sizes of disturbances in the atmosphere. The lifetime of a disturbance is related to its size.

Their predictability is related to their lifetime and size.

- The largest disturbances are planetary waves (known as Rossby waves, as depicted in the sculpture on the right), best seen in the meanderings of the jet streams, at aircraft cruising altitudes, which guide the development and movement of weather systems around the globe. They have a length scale of around 10,000 km, evolve on a timescale of several days to a week, predictable for one to two weeks ahead.
- Bands of weather associated with depressions and fronts are typically 100 km across, evolve on a timescale of 12 hours and are predictable up to about one or two days ahead.
- Much of our severe weather comes from disturbances of the size of a thunderstorm – about 10 km – lasting an hour or so. We can predict these up to about three hours ahead.
- Very small disturbances such as tornadoes may be only 1 km across, last for about 10 minutes and are predictable for only half an hour ahead.
- While individual storms causing severe weather may only be predictable for a few hours ahead, the likelihood and intensity of storms in an area can often be forecast much further ahead.



Seasonal forecasting

FACT 8 — Seasonal forecasts provide information on how weather, is expected to vary from normal.

Seasonal forecasts incorporate more of a global view to look out a month or more into the future. They factor in details such as the current average state of the atmosphere and the ocean at distances often thousands of miles away from the specific location of interest.

The same computer models of the atmosphere that are used to make daily weather forecasts are used for seasonal forecasts, with some differences:

- They are run forward in time up to many months ahead, rather than just for a few days.
- They include active oceanic, as well as atmospheric, components.
- They are run many times, with slight variations to represent uncertainties in the forecast process.

Long-range forecasts estimate only the average weather, not specific weather events. Therefore, in seasonal forecasts, phrases such as 'warmer than normal' and 'wetter than normal' are common.

Seasonal forecasts are indications of an overall picture because, unlike short and medium range forecasts, it is impossible to forecast individual events so far ahead. Because of uncertainty in forecasting at long range, seasonal forecasts are generally expressed in terms of probabilities.

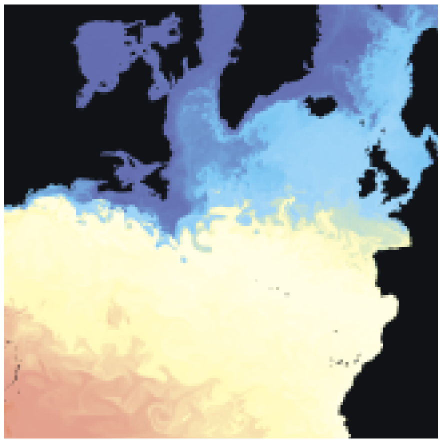
Sea-surface temperature

Natural variations of the Earth's climate that vary over long periods of time can influence weather patterns. Fluctuations in the surface temperature of the global oceans are particularly influential.

The influences are not easily noticed in day-to-day weather events but become evident in long-term weather averages.

Slow fluctuations of sea-surface temperature (SST) can be predicted, to some extent, at least up to six months ahead.

The links between SST and weather can be represented in computer models of the atmosphere and ocean. Computer models developed at the Met Office, like those used in making both daily forecasts and long-term climate change predictions, form the basis of our seasonal prediction systems.



We don't just forecast 'bad' weather

FACT 9 — We don't just forecast 'bad' weather.

It is our duty to warn people of adverse (or high impact) weather conditions. On occasion, we have been accused of being too pessimistic in our forecasts – often when we are forecasting severe weather events such as heavy rain or snow.

However, it is also our duty to tell it like it is – we aim to provide accurate forecasts that give people the facts so they can make the most informed decisions. In some cases, warnings criteria have been agreed with customer groups based on impacts that affect them specifically.

We aim to achieve a balance between not missing important weather events while not 'over-warning'.

National Severe Weather Warning Service
We warn people of severe weather under the National Severe Weather Warning Service (NSWWS). We use Nowcasting to decide when a 'Flash warning', which indicates a high confidence of severe weather in the next few hours, needs to be issued.

Many forecasts are provided to our customers in this time range, for example to those who have to respond to emergencies, such as flooding, like the Environment Agency.

In addition to short period 'Flash warnings' we also issue warnings of potentially severe weather up to several days ahead via NSWWS 'Early Warnings' and 'Advisories'.

These services differentiate between two levels of severity and three levels of likelihood, with the highlight advice given as a traffic light code indicating:

- Green (no severe weather likely)
- Yellow (for information)
- Orange (be prepared)
- Red (take action now)

Not only do these warnings inform the general public via our website, emergency planners also use them to make strategic decisions.

Collaboration is essential

FACT 10 — Collaboration is essential for accurate weather forecasts.

Weather takes no notice of boundaries between countries and continents so it's vital that our forecasters and researchers work with other national weather services to make the most use of the information about the atmosphere.

This is true for operational forecasting, but also for the research that underpins our forecasts. Our scientists work closely with organisations from all around the world.

We strive to build academic and research relationships with other centres of excellence, by combining skills, capabilities, and aligning research and development programmes.

As the Met Office has a reputation as one of the best weather forecasting services in the world we are a partner of choice for many organisations around the world.

To improve our forecasts further, we're actively involved in a number of international programmes, projects and initiatives, working with other partners to improve our joint capability and understanding of science.

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