Met Office

Barometer

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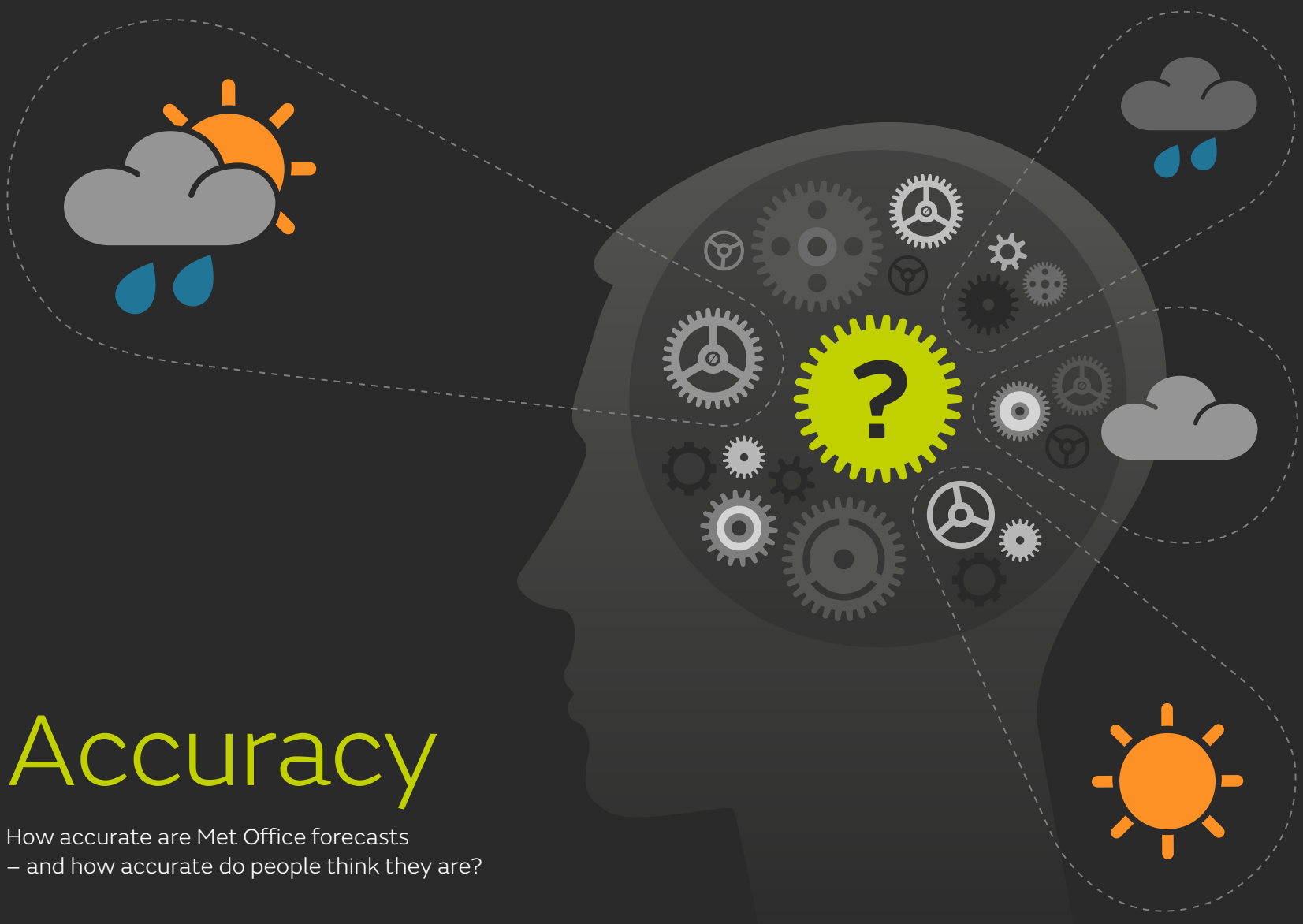

Accuracy

How accurate are Met Office forecasts
– and how accurate do people think they are?

As she reaches the end of her eight years as ***Chief Scientist***, ***Julia Slingo*** reflects on how ***Met Office*** science has evolved and what the future holds.

Looking to the future

I arrived at the Met Office in 2009 with a desire to see the science we do, increasingly with partners in universities and other research institutes, make a real difference to protection, prosperity and well-being.

One unique attribute of the Met Office is the combination of weather and climate science and services in the same organisation. I have always argued that there is no difference between what we need to know about tomorrow's weather and what our weather will be like in 50 years' time as our planet warms. It's the same fundamental science and we can employ the same fundamental models to make predictions.

It has been immensely rewarding to see barriers between weather and climate science and services gradually dismantled. We now have a single, unified science programme with common threads running through it. We know that we must simulate global weather and climate to forecast at the local scale for the UK. We also know that the biggest impacts of climate change will be felt through changes in hazardous weather and climate extremes at the regional and local scale.

We were able to exploit these common threads in our response to the National Flood Resilience Review (NFRR) (see page 5) when we were asked to provide plausible worst-case scenarios for UK rainfall for the next 10 years. The UK's weather is highly variable and recent extreme flooding events often have their origins on the other side of the world. So how bad could our weather and therefore rainfall and flooding be?

As well as developing our science to tackle issues at the global to local scale, we have also advanced capabilities in ensemble prediction so we can talk about the probabilities of specific weather and climate events (see page 6). We usually employ these in forecasting, but we can equally apply the concept of 'one flap of a seagull's wings will forever change the future course of the weather' to explore the myriad of paths that the world's weather could take – beyond what we have been able to observe over the last few decades – and find instances of even more severe weather. In the NFRR we were able to show that even more extreme rainfall is possible and to use these scenarios to stress test the Environment Agency's assessments of flood risk.

Using climate and weather simulation to find plausible examples of more extreme conditions than we've observed so far – what we might call 'black swans' – is an exciting development which could revolutionise how we approach future assessments of weather, climate and environmental risk. We are increasingly aware that exposure to extreme weather and climate events could potentially threaten securities on which we rely – food, water, energy, health to name a few – and to derail the sustainability of economic development and social welfare in the developing world. This places Met Office science at the heart of national and international agendas to manage future risks, and adapt to and mitigate future climate change.

None of this would be possible, though, without substantial investments in supercomputing (page 4). The investment in our latest facility is designed to unlock the potential in our science to deliver actionable advice and services that make a real difference around the world (page 20).

With these solid foundations I have every expectation that Met Office science will continue to thrive and I give my successor, Professor Stephen Belcher, my very best wishes for the future.

November 2016

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In this issue...

In brief

A quick look at the news and updates from around the world of the Met Office.

New look weather for ITV

In October we started our new weather service with ITV across its national and regional channels.

The broadcaster signed a new contract with us for the next five years for Visual Cortex, our new visualisation system. As well as Visual Cortex, ITV is also using our new Public Weather Media Service (PWMS) which includes forecasts, weather warnings, observations, guidance, scripts and advice from our media services team.

Michael Jermey, ITV's Director of News and Current Affairs, said: "The new ITV graphics sees the traditional graphics and symbols of previous broadcasts being replaced with high-resolution maps which accurately reflect the world viewers live in. The dynamic weather effects and detailed local breakdown across the UK will help the audience understand what to expect hour-by-hour through the day."

Greg Clarke standing down

After more than four years as our Chairman, Greg Clarke has stepped down.

We have seen some important changes while Greg has been Met Office Chairman – the biggest ever investment in our supercomputer, the establishment of our Business Group and the General Review, which quantified the huge social and economic benefits that the Met Office delivers.

Professor Sir John Beddington is acting as Chairman during the recruitment process to find Greg's replacement. Greg has been appointed Chairman of the Football Association – a role which will take up a significant amount of his time. There are interesting parallels as Greg moves between two organisations that are both the subject of national conversation on an almost daily basis.

Greg said, "It has been a pleasure and a privilege Chairing the Met Office. It is a world class organisation, filled with excellent people doing vital work."

What's in a name?

Once again, we will be naming storms this autumn and winter to raise awareness of severe weather.

Last winter, working with the Irish national meteorological service, Met Éireann, we piloted a scheme to name storms that were forecast to impact the UK and the Republic of Ireland.

With support from our partners and the media, naming storms proved very successful, providing a single authoritative naming system for storms that affect UK and Ireland. It also raised awareness of severe weather before it hit, helping people keep themselves, their property and businesses safe.

Storm names were widely used by the public, media, partner and responder organisations. Every storm name trended on Twitter, with over half a million tweets using storm name hashtags. We even won a Social Buzz Award for Best Public Sector Social Media Strategy/Campaign.

Now, together with Met Éireann, we are running a second pilot for a year. The new list of storm names is published on our website and the criteria for naming remains linked to the National Severe Weather Warning Service of the UK and the Republic of Ireland.

We will improve things by highlighting other high impact weather as well as wind, such as heavy rainfall. We will also make it much clearer when the named storms are affecting the UK and when they have finished.

See our Storm Centre at **www.metoffice.gov.uk/uk-storm-centre**

The new supercomputer is live

In February 2016, weeks ahead of schedule, the Met Office implemented the second phase of its new high performance computer (HPC), or new supercomputer.

Where the first phase had been a like-for-like replacement of its predecessor, this was an upgrade delivering six times more power and making it the largest operational HPC in Europe. Perhaps more significantly, this increased capability was already being exploited within just three weeks of its delivery.

As David Underwood, Deputy Director of the HPC Programme explains, "This implementation has given us the biggest improvement in the Global Model's performance that we've seen in a decade."

Heralding a new era

Improving the quality of the Global Model enables more accurate forecasts over longer time periods, more detailed forecasting of weather and increased detail at a more local level – and this is just the beginning. The final phase is expected to be delivered months ahead of the 31 March deadline – and with it comes a step change for meteorological research as a whole.

As David states, "This is a real milestone for the UK, putting the Met Office at the forefront of weather and climate science, and enabling it to exploit that science to help its customers protect infrastructures, preserve life and promote prosperity."

As the largest machine in the world dedicated to meteorological services, the fully operational HPC will be able to run 16,000 trillion calculations per second. This mind-boggling speed means the Met Office can translate ever more refined and complex scientific knowledge into effective products and services that bring tangible benefits.

Lasting benefits

These benefits span every sector. For example, more accurate wind forecasts should enable the aviation industry to better plan flight paths and reduce fuel consumption, and the renewables industry to reduce the risk associated with offshore wind resources.

More detailed and accurate advanced warning of potential flooding and severe weather should help increase winter resilience and help better protect businesses, assets and the public. And in the long term, high resolution climate models and more complete Earth System models provide the opportunity to better assess future impacts of a changing climate.

Fast facts about the new supercomputer

Name: Cray® XC40™

Location:
Partly at the IT halls at the Met Office HQ in Exeter, partly at a purpose-designed building at the nearby Exeter Science Park.

It will:

Be one of the **twenty** fastest computers in the world

Run over **16,000 trillion** calculations per second (16 petaflops)

Weigh **110 tons** equivalent to nine double decker buses

Have **1.6 million** gigabytes of memory (1.6 petabytes), equivalent to over **100,000** iPhones

Have **23 million** gigabytes (23 petabytes) of data storage enough for over **100 years** of HD movies

A five star review

When the Government set up the National Flood Resilience Review, the Met Office played a central role.

Following the extreme rainfall and flooding in Cumbria in December 2015, the Government set up the National Flood Resilience Review (NFRR) to assess the risks of flooding across England.

The review quickly became a priority after serious flooding hit York on Boxing Day. The NFRR modelling was led by the Environment Agency with the Met Office contributing weather and climate expertise. Our contribution was led by Ian Lisk, Head of Environmental Hazards and Partnerships at the Met Office.

"The Met Office was asked to generate a set of plausible extreme rainfall scenarios based on innovative use of the latest advances in our weather and climate modelling science," says Ian.

The Met Office also looked at whether the recent run of extreme rainfall events reflects an underlying trend in the frequency of extreme weather. While there is evidence that climate change is

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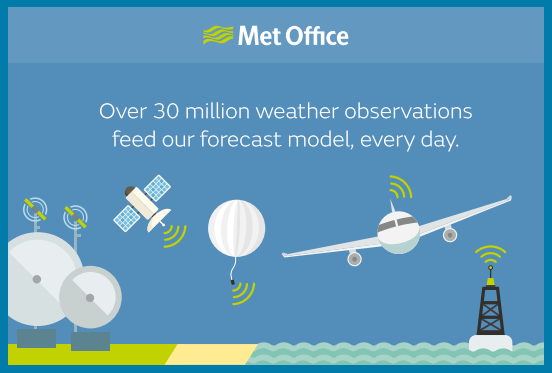
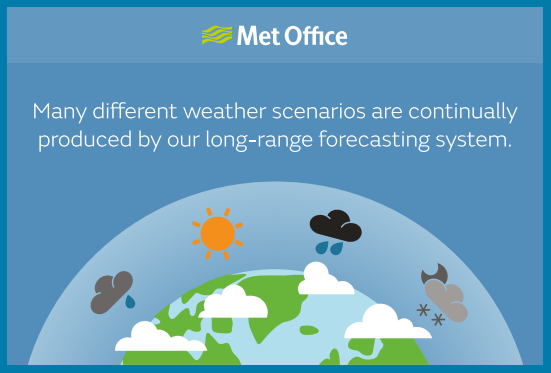
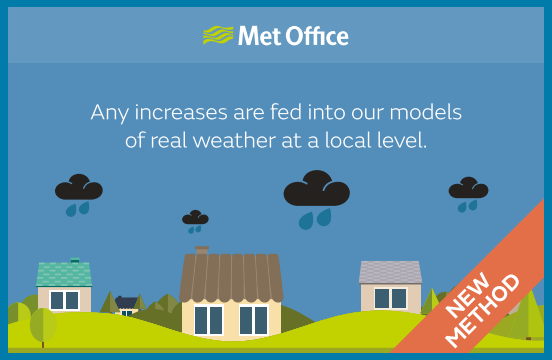
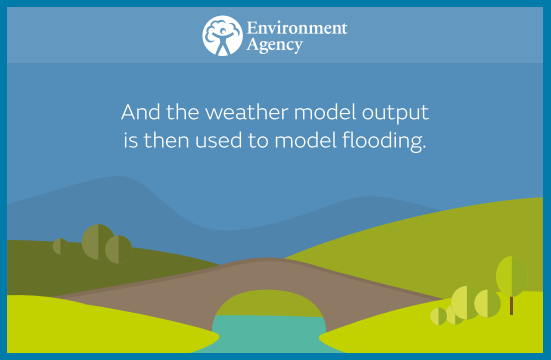




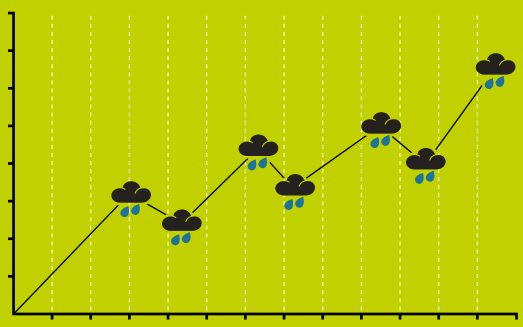




affecting rainfall over the country, for the review we concluded that variability due to natural processes will continue to dominate in terms of extreme rainfall over the next ten years. “Our plausible extreme rainfall scenarios were run through the river models of the six catchments chosen by the Environment Agency as a stress test of their existing flood risk assessments,” explains Ian.

The process used in the review will also help to inform future flood risk assessment strategies. “The intention now is to use the techniques we’ve developed more widely to help inform the next National Flood Risk Assessment in 2018,” says Ian.

“Beyond that, in line with NFRR recommendations, we’ll be looking to work with partners on better linking up meteorology, hydrology and flood modelling science through the development of a more integrated flood risk modelling approach,” he added.



Leading the way in data

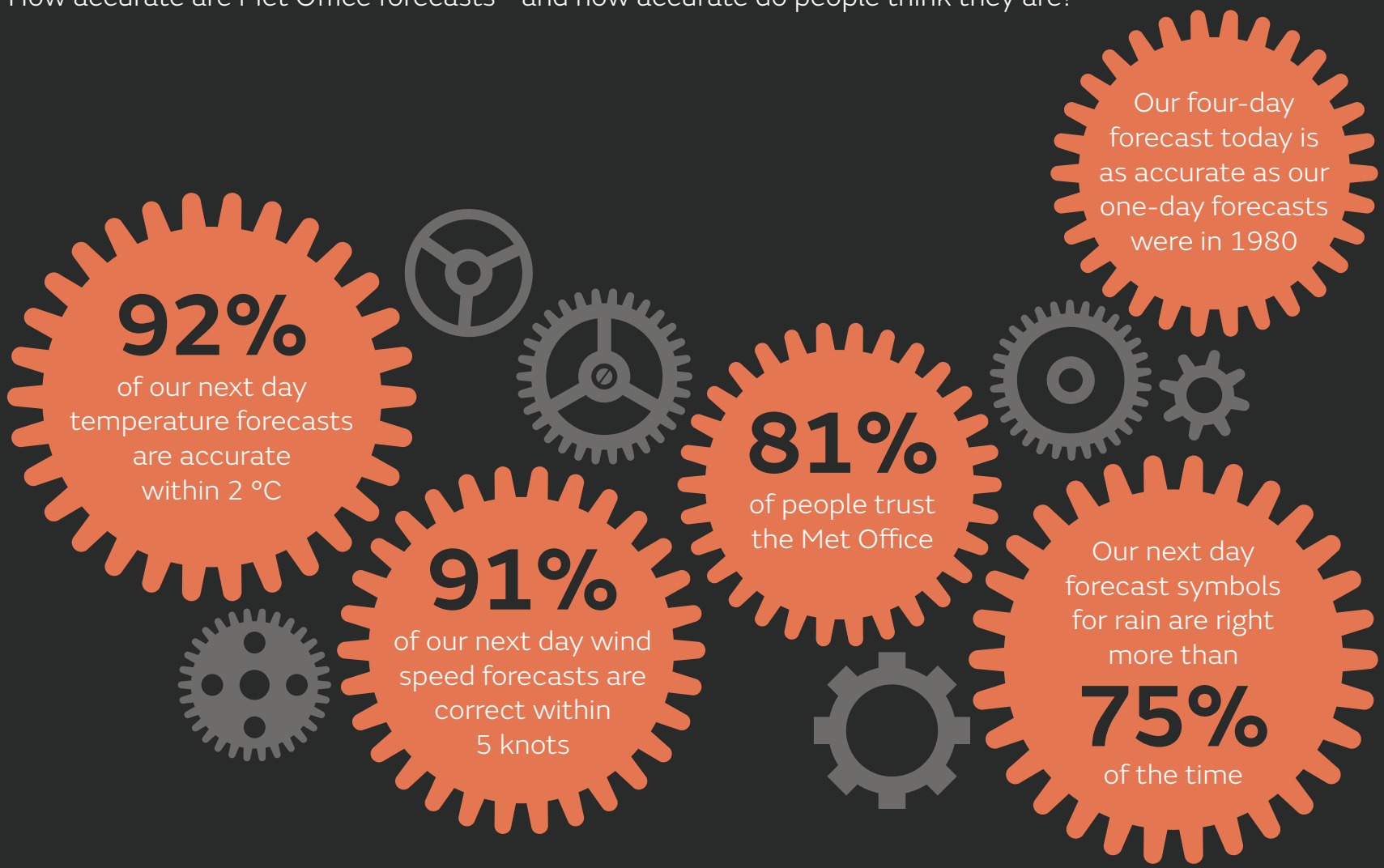
We were asked to develop extreme rainfall scenarios that were scientifically valid and plausible. Our novel and innovative approach taken was endorsed by the NFRR’s Scientific Advisory Group and corroborated by results from the European Centre for Medium Range Weather Forecasting.

The state-of-the-art Met Office Hadley Centre climate model produced over 11,000 monthly rainfall scenarios for six large regions in England and Wales and for the current climate. These were used to sample many more cases than are available from existing observational records, including several hundred extreme regional rainfall events that are meteorologically possible but lie outside what has been experienced based on our observational records.

The chance of extreme events like these happening was then estimated. The results suggest there is a 1% likelihood every year that winter monthly rainfall totals could plausibly be 20% higher than recent past extremes in some parts of the country and in other areas up to 30% higher than recent past extremes. Over any of the large regions there is also around a 10% chance in any given year of existing monthly rainfall records being matched or broken.

Perceptions of accuracy

How accurate are Met Office forecasts - and how accurate do people think they are?



Every provider of weather forecasts needs a means of validating how well they are performing and the Met Office is no exception. Verifying the accuracy of our forecasts is one key way to measure performance enabling us to test the performance characteristics of our models and identify areas of research needed to make improvements. We do this by testing various parameters – such as temperature or wind direction – against actual observations and then assessing performance trends against established benchmarks. It may sound straightforward, but with the Met Office issuing thousands of forecasts every day, how do we decide which parameters to verify? Here's where the science becomes something of an art, as Richard Orrell, Deputy Head of the Public Weather Service, explains:

> *"The key is being able to assess how well we're doing around the criteria that matter to our customers."*

"The key is being able to assess how well we're doing around the criteria that matter to our customers. We spend a lot of time working with people who use our services to find out what those criteria are." For example, while a key concern for members of the public is whether it's going to rain or not, an aviation customer primarily wants to know the wind and temperature forecasts at cruising altitude, or whether the weather at destinations is likely to cause problems on arrival.

Staying relevant

How the accuracy of these different parameters is measured also varies according to the needs of the end user. For example, 'percentage of correct forecasts' may be a general and accessible measure, but it may be less relevant to a transport network customer more interested in unusual or severe weather. With this in mind, the Met Office gears statistics and measures to the specific requirements of each customer, ensuring they stay relevant and useful.

While the focus is on establishing and communicating the objective truth behind the science, understanding the perceived truth is also key. Different people experience the weather differently, in different places and at different times of year. The context in which a forecast is used also has a significant impact on perception. This inevitably influences their perception of a forecast's accuracy. Other potential drivers could include brand affiliation, usability of the product, how weather dependent a person's job is, and so on. The Met Office is looking at identifying these drivers with a view to potentially tracking them in the future.

Redefining success

The rise of social media has added a further element to an already complex picture, with likes, comments and dislikes also influencing how forecast accuracy is perceived. While this presents challenges, opportunities also abound, such as mining data from social conversations to gain insights into where and how the weather is affecting people.

The Met Office is also embracing 'citizen science'. For example, we are working with local Flood Action Groups to see whether they can engage local communities in providing weather impact reports. Not only could this information help with verification, it could also enhance how the Met Office validates success. As Richard says, "We can objectively define our accuracy, but if that doesn't correlate with people's perception, we have to redefine what success actually is."

> *"The rise of social media has added a further element to an already complex picture, with likes, comments and dislikes also influencing how forecast accuracy is perceived."*

Changing expectations

So, if accuracy is improving, why has the public's perception of forecast accuracy remained relatively unchanged at around 77% over the last decade? There are many factors but the answer could partly be in the correlation between consistency and perceptions of accuracy: for instance it is possible for the public to receive differing forecasts from different providers, so they perceive that the forecast is inaccurate. One other factor may be that people's expectations have risen to the point where they expect more. This is particularly true in a world in which people are used to constant updates and information on demand.

Surveys tell us that 87% of people trust the Met Office. As ever, our challenge is to raise the public's confidence in forecast accuracy further, quantify the inherent uncertainty within a forecast and communicate a consistent message across different channels.

Getting better all the time

Are the Met Office's forecasts getting better? Answering this question relies on establishing a benchmark.

To make sure individual weather events or seasonal influences don't skew results, the Met Office takes three years of performance data to establish benchmark measurements – even longer for unusual or severe weather.

Against these set benchmarks, Met Office forecasts are generally improving at a rate of one day of additional accuracy per decade. In other words, a three-day forecast today is about as accurate as a two-day forecast was a decade ago. This is true for surface pressure but does vary for other parameters as some types of weather are easier to forecast than others.

According to methodology set by the World Meteorological Organization (WMO), the Met Office's global Numerical Weather Prediction model is the most accurate operational model in the world. Accuracy varies between forecasts, but as an example, one-day temperature forecasts in the UK are 95% accurate within two degrees of the observed temperature. This accuracy decreases the further ahead you look, so the five-day temperature forecast is 75% accurate.

What do 17th-century mathematician Leonard Euler and 1980s television weatherman Ian McCaskill have in common? Both, at one point or another, have inspired Dr Anthony Veal, Senior Scientific Consultant at the Met Office. Today he's fascinated by the effects of weather and climate on all parts of society – from those simply trying to get from A to B, to people with serious respiratory problems.

On the road for

Seeing an energetic weather presenter jumping around in front of colourful maps first piqued Anthony Veal's interest in the weather, aged seven. Going on to study Environmental Sciences at the University of East Anglia, he spent a 'sandwich year' in the US where he also tried out broadcasting for himself. "It was partly because I had an English accent," Anthony confesses. "But I knew about the weather, so I read the forecast on student radio."

By the time he began an MSc in Applied Meteorology and Climatology at the University of Birmingham, Anthony knew he wanted to explore how the weather impacts everyday life. So, after adding a PhD in air quality, he joined the Met Office in 2001.

Making a difference

When working with the Health team at the Met Office, Anthony drew on his doctorate in air quality to help create a weather model for COPD (chronic obstructive pulmonary disease), a severe respiratory condition. He and the team spotted links between

key weather patterns at certain times of the year and increased hospital admissions. “Our model enabled the NHS to inform vulnerable patients, ahead of a weather event, to up their medication and control their condition, keeping them well – and hopefully out of hospital,” he explains.

Now, he has an impressive title: expert in climatological statistical analysis and presentation methods. But, put simply, Anthony says his job is to turn complex weather and climate information into something a customer can use. For Anthony, variety is one of the great pleasures of his job.

“What I like most about the Met Office is how many opportunities I have to apply my scientific knowledge to tackle all sorts of issues.”

Putting weather on the map

Finding ways to communicate detailed weather data to the Met Office’s range of clients has seen Anthony draw on his academic studies and his extra-curricular

“At the Met Office, we’re always looking at how we can use the advanced technology at our fingertips for socio-economic good.”

But Anthony stresses that it’s not just collecting the data that’s important – it’s how you deliver it.

“We use cutting-edge scientific methods and technologies like GIS, but we need to turn the very detailed, complex output into something that’s meaningful for our customer,” he explains.

In fact, he describes his role today as bridging scientific investigation and customer liaison, for a range of surface transport organisations, such as Network Rail.

getting it right means we’ve saved them 15% in fuel and 12% in fleet costs.”

The Met Office also recently completed a project covering Northern Ireland’s 7,000 km long gritting network. The client optimised their routes several years ago, but wanted to revisit them to see if further savings could be made down the line. “Doing that requires huge investment of time and money,” says Anthony. “So I suggested a short desktop study first.”

Running a pre-project prediction study was new. But it paid off. By analysing the client’s treatment data, Anthony predicted they could save three to five gritting routes – a small number but a significant sum of money. After 18 months careful analysis his colleague Emma Smith successfully achieved a four route saving.

Looking back. Driving forward.

Reflecting on his 15 years at the Met Office, Anthony’s favourite part of his role is still what drew

greater good

University activities. “I’ve always been fascinated by maps, ever since I ran my University walking club,” he remembers. But instead of using them to ramble through the Lake District, Scotland and Snowdonia, he’s now consulting maps slightly differently.

Much of Anthony’s work involves GIS – geographical information systems that map and analyse spatial data. It became a crucial tool in a Network Rail project that examined the cause and effect of poor rail adhesion – when snow, rain and leaves blown on to tracks can lessen traction.

“Using GIS, we discovered that small amounts of moisture on the rails from dew, drizzle and fog make them very slippery, and demonstrated that this was just as important as leaves on the line.”

Then, when Heathrow Airport needed a new network of weather sensors, Anthony designed survey routes and the team was carefully escorted up and down runways and taxiways in a vehicle specially modified to measure air and ground surface temperature.

On the road

Very recently, Anthony partnered with Kier (which manages part of Highways England’s network) on a major project to optimise gritting routes in the Midlands. “The Met Office is unique because we can find the most financially and climatologically efficient routes that ultimately keep traffic flowing in wintry weather,” says Anthony.

Kier presented the Met Office with a challenge: their gritters have a short, two-hour window in which to cover a widespread intricate network – without running out of salt. So Anthony carefully set up and calibrated a model that coped with the complexities of Birmingham’s spaghetti junction and proposed a new set of routes. These were fed into cab-mounted GPS to guide drivers around the most efficient route.

“Our aim was to get the most out of each vehicle – going as close as possible to the two-hour limit without running out of salt or missing a motorway slip road. It’s a really delicate balancing act. But

him here: applying meteorology to benefit everyday life. That means pushing science forward to solve problems – and never knowing exactly what the next project is going to involve. And it still throws up plenty of surprises. “The most rewarding thing is always when a customer turns to me and says ‘that’s amazing – we really didn’t know the Met Office could do that’.”

Blazing a trail for climate services

Day to day, most of us make decisions based on the weather forecast. But in industries such as transport, renewable energy and food security, people need to look further ahead to what the next season, few years or even decades, could hold. Over the past four years, the Met Office has been coordinating a ground-breaking project to improve climate services in Europe: EUPORIAS.

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EUPORIAS, which stands for the European Provision Of Regional Impacts Assessments on Seasonal and decadal timescales, was set up in 2011 to explore how climate forecasts can be turned into services tailored to specific industries. Funded by the European Commission, the project brings together 24 partners – with the Met Office leading the way. These include national meteorological services, universities, energy companies and organisations such as the World Food Programme and the World Health Organisation. Dr Carlo Buontempo, Science Manager at the Met Office, has been coordinating the science of the project since day one.

"The Met Office was seen as a very credible leader for developing climate services," says Carlo. "We put together a proposal for a four-year work plan and found a strong group of partners to work with. Each has different tasks and deliverables but it's very much a collaborative project."

World-leading research

EUPORIAS began by assessing how climate information is currently used in Europe. This included finding out who the main users were and understanding their needs. Carlo points out that such detailed information about what users need from climate predictions over seasonal and decadal timescales has never been gathered before, and is essential for pinning down how services can be improved.

With this vital first step in place, the partners embarked on a research programme focused on improving how climate models are used to make predictions. For example, some looked at how climate models – which run at a lower resolution than short-term weather forecasting models – can be downscaled to zone in on smaller regions. The Met Office explored how to better represent uncertainty from the model when predicting how climate will impact specific users.

Next came the challenge of exploring how this complex information could be presented to people in a variety of industries in a way that helps them make critical operational decisions. This stage was structured around developing a set of six climate-forecasting prototypes for diverse sectors including food security, water security, land management, transport, hydropower and wind energy. Many of these are now semi-operational and, as Carlo explains, demonstrate how important it is to tailor climate services to specific users:

"The needs of, for example, the World Food Programme looking for an early-warning system for drought in Ethiopia are very different from the requirements of West of England farmers planning what crops to plant. Which means, if we created a generic service, they wouldn't get all the information they need. Through EUPORIAS we've found that to be truly useful, climate services have to be targeted."

A guiding light

As well as boosting the Met Office's reputation as a leader in climate services, EUPORIAS is a great example of international cooperation which will continue to have a lasting impact. Although the EUPORIAS project ended in October the Met Office will continue to collaborate with international partners. Carlo explains that, in addition to new research, one of the major successes of EUPORIAS has been that the lessons learned can be fed into other climate service initiatives, the world over:
"Even though the aim of EUPORIAS was to be very specific in the prototypes it created, the experience – including how we worked with the users to create the prototypes, and managed their expectations about them – can be applied on a much wider scale. To me, that's one of the most important legacies of this project."

Forecasting gets personal

As part of EUPORIAS, six semi-operational forecast services were developed for sectors ranging from water security to renewable energy. We look at two to explore how targeted climate services mean it's not just what you say, but how you say it that matters.

RESILIENCE: wind speed forecasts for the renewable energy sector

The renewable energy sector had been relying on wind speed forecasts that stretch just two weeks ahead. Working with wind farm operators and energy traders, EUPORIAS identified that longer-term forecasts could really boost the efficiency of their operations. For example, commissioning new wind farms in strong seasons could hasten a return on investment, while planning maintenance for weaker periods could minimise the cost of missed energy generation.

With energy companies running wind farms dotted across the globe, there are lots of users interested in accessing this information. So EUPORIAS landed on an innovative data visualisation that shows the probability of high and low wind speeds on a global, seasonal scale, accessible online.

SPRINT: seasonal weather impact predictions for the UK transport network

From flooding to icy roads, winter weather has a huge impact on the UK transport network. But how do we know if we should stock up on sand bags or grit? Understanding the North Atlantic Oscillation (NAO), in which strong westerly winds can lead to mild, wet conditions, and weak ones can cause cold, dry weather, is an important factor in seasonal weather forecasts.

With an existing relationship with the Department of Transport, the Met Office explored how the seasonal forecast could better communicate the impact NAO was likely to have on the weather. As the stakeholders here were well defined, developing an online data visualisation, as with the RESILIENCE prototype, was not the best option. Instead, stakeholders could attend an annual workshop ahead of the cold season, where Met Office meteorologists could talk them through the seasonal forecast in detail.

Find out more at **www.euporias.eu/prototypes** and **www.metoffice.gov.uk/research/collaboration/EUPORIAS**

A day in the life of an aviation meteorologist

Commercial airlines striving to keep to their tight schedules. Military pilots flying off on training exercises. Right across the aviation sector, the Met Office is there to provide the detailed weather advice that's crucial to keeping operations running smoothly. But what's it like to offer on-the-ground support to this highly weather-sensitive industry? Two aviation meteorologists give us an insight into their day-to-day work.

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Planning ahead

Emma Corrigan, easyJet Operational Headquarters

With over 200 aircraft criss-crossing Europe's skies, easyJet relies on confident forecasts to mitigate any impact the weather may have on their daily operations. As flights start from 6am, the busiest part of the working day for meteorologist Emma Corrigan is often before most people have woken up.

"The morning shift begins at 4am and the next two hours are filled with particularly intense activity. This includes looking at the general weather situation, then focusing on anywhere easyJet is particularly concerned about to give them more detail."

Tailored forecasts

The skill of working as an aviation meteorologist involves giving clients complex weather information in a way that best helps them make important decisions. At easyJet, this can mean homing in on their most popular flight routes and airports.

"Aircraft can sometimes do six flights in one day, so if a morning one is delayed it can have a knock-on effect that could have the negative consequence of delays impacting on customers," says Emma. "I produce a daily weather summary that highlights the risk of potential impacts. When there is difficult weather around easyJet's main bases, such as where aircraft and crew are stationed, we tend to see a much higher impact than at smaller airports which may only have one flight a day."

Instant feedback

After creating the forecast, Emma briefs everyone from engineers to executives on the day's weather, as well as giving them a five-day outlook. She also talks to pilots about the weather forecast for their route – including sending up-to-the-minute information to them while they're in flight. For Emma, it's the chance to work so closely with the company that she finds most interesting. "You can see how your advice affects the decisions they make. It makes it really enjoyable when your information helps keep their programme on track."

And the biggest challenge? The changeability of the weather. As Emma explains, "meteorology isn't an exact science. Sometimes we'll be faced with a marginal weather situation that could go either way. You have to be confident in the advice you're giving, and not sit on the fence."

A personalised approach

Catherine Maguire, RAF Linton-on-Ouse

If aviation meteorology means tailoring forecasts to offer the most useful advice, working in the defence sector takes this personalised approach to a new level. Catherine Maguire, stationed at an RAF base that trains fast-jet pilots, often finds herself advising individual pilots on the routes they plan to fly.

"They might say, 'I'm flying from Yorkshire to the north of Scotland via these valleys'", says Catherine. "Because their aircraft are much more sensitive to weather than commercial jets, they need to know about small fluctuations in weather conditions for the entire journey."

The weather in brief

Catherine's working day begins at 5.30am, when she gets up to speed with the day's weather, then briefs pilots and operational personnel ahead of the first training flights. Due to the different limits that the trainee pilots can fly at, such as the cloud base and wind speed, these briefings have to be extremely detailed.

"Sometimes I'll brief groups as small as two or three pilots. Experienced pilots can fly in most weather conditions, but the trainees are far more sensitive to weather. For example, a difference of a few hundred feet in the cloud base can decide whether someone will fly or not, so you do have to be incredibly specific."

Staying up to date

After the briefings, Catherine is on hand to answer enquiries and create ad hoc forecasts, including advising about conditions that could affect ground-level operations at the base. For instance, as the RAF is responsible for gritting its own roads, a heads-up about icy conditions can help make sure people and resources are available to get the job done. As might be expected, it's the weather that makes a difference to the day's workload.

"Although the structure of each day is the same, what I do depends on whether there's hazardous weather forecasted", explains Catherine. "If there are thunderstorms or low cloud coming in, I'll have lots of enquiries from pilots. And if conditions change faster than expected, I'll get in touch with flight operations who can call the pilots back if needed. It's all about constant communication."

Don’t get left in the dark

Weather has many impacts, and can sometimes disrupt power supplies. Would you know what to do in a power cut? Now the new 105 telephone line is free to call, and connects you to your electricity network operator so you can get the information you need on your power supply – something that is especially useful during adverse weather conditions.

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As days get shorter and winter draws in, across the UK we begin to brace ourselves for wetter, windier weather. Moving into the latter part of the year, storms are on the horizon – with conditions increasing the likelihood of flooding, as well as strong winds or lightning, which can all cause damage to vital infrastructure such as power lines.

This can mean disruptions to people's electricity supply. Indeed, last year, Storm Desmond caused power cuts for thousands of homes in Cumbria, as well as severe flooding which caused bridges to collapse and left members of the community stranded.

Significant investment by electricity network companies means that power cuts aren't an everyday occurrence for most us. However, if they do happen and you're elderly, medically dependent on electricity or have young children they can be more than just inconvenient.

What to do during disruption

While a more robust power network is good news it does mean that many people just don't know what to do if they do have a power cut. In fact, recent research commissioned by Energy Networks Association found that 72% of British people don't know who to contact, with 43% incorrectly contacting the company they pay the bills to (their energy supplier) to report a power cut.

In fact, the organisations that can help are the network operators – organisations the public rarely has a need to contact. Network operators play a vital role managing and maintaining the power lines and substations that deliver electricity into homes and businesses across the UK. There are several network operators serving the UK, and the one which looks after your local electricity power lines depends entirely on the area you live in. However, latest research found only 11% of the British public could correctly name their local operator, showing just how many people are unaware of what to do if the lights do go out.

Connecting consumers

To help change this and support customers the electricity network operators have worked in partnership with Energy Networks Association (ENA) to fund and create 105 – a national, easy to remember number for people across England, Scotland and Wales to report or get information about a power cut.

105 is free for anyone to call, regardless of who they pay their electricity bills to, and can be used on landlines and mobiles. It will connect consumers directly to their local electricity network operator enabling them to get the information they require, as well to report any damage to power lines or substations, something particularly useful if their area is experiencing adverse weather conditions.

By providing a simple, memorable number, which customers are being encouraged to save in their phones, ENA hopes that people will find it simpler and easier to be put through to the people behind the power who can really help. It will still be possible to contact local electricity networks directly, via their social media channels, website or direct phone number.

Mel Harrowsmith, Head of Civil Contingencies at the Met Office said, "In the run up to a storm it's still important for people to keep an eye on weather forecasts and impacts, but with the 105 number people are now better armed to deal with any potential power cuts this autumn and winter."

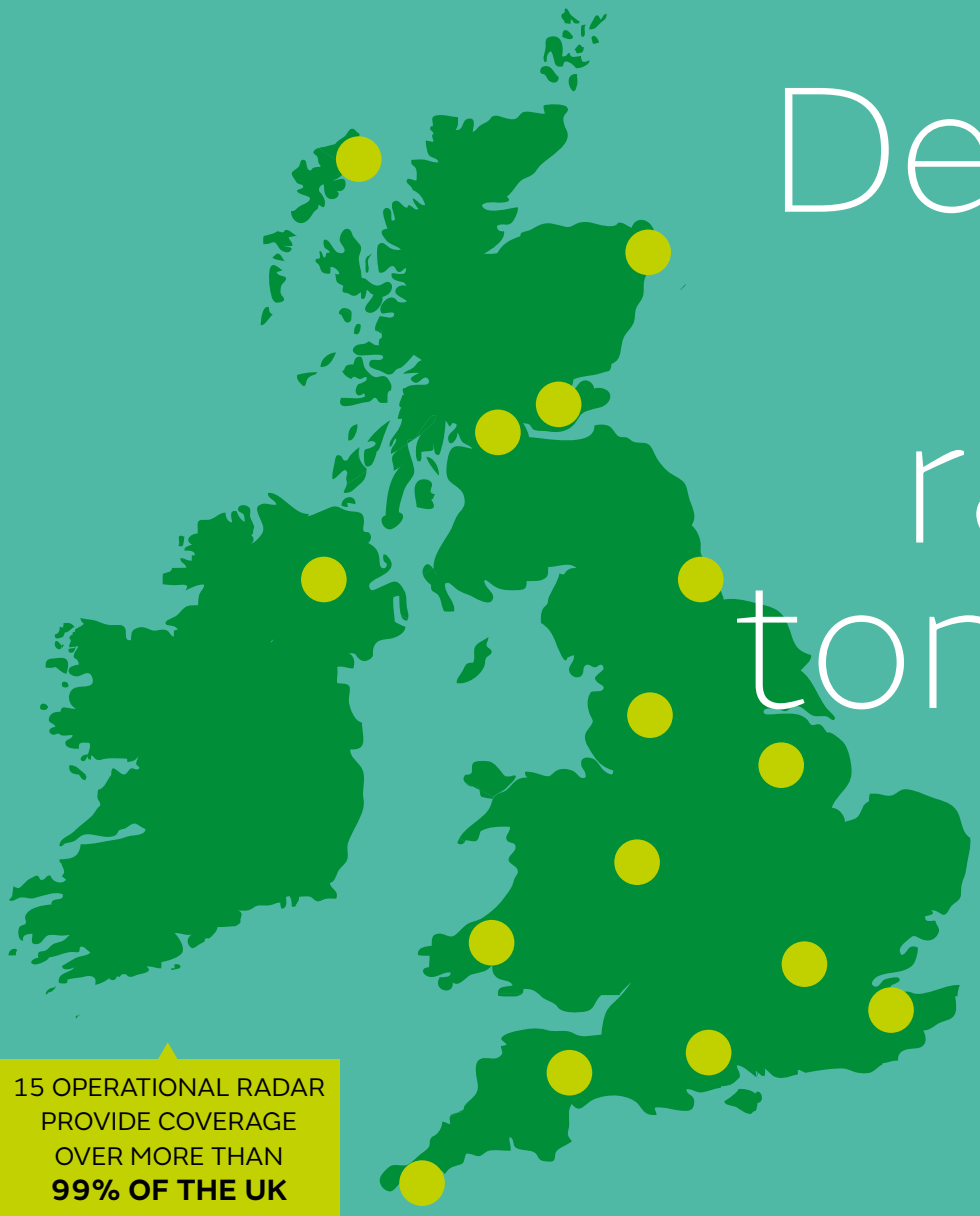
Energy Minister, Baroness Neville-Rolfe, also commented: "For the first time, customers across the country will have a quick and simple way of getting information on power cuts affecting their households. It also allows the public to report any damage to electricity power lines and substations that could put themselves, or others at risk. 105 is a memorable number and you can also save it to your phone."

powercut105.com

105 is supported by powercut105.com - a new website which will route those who prefer to go online for support to their local network operator. It also provides advice on what to do in a power cut such as:

- **ALWAYS SWITCH OFF ELECTRICAL APPLIANCES THAT SHOULDN'T BE LEFT UNATTENDED, BUT LEAVE A LIGHT SWITCH ON SO YOU CAN TELL WHEN THE POWER HAS COME BACK ON**
- **CHECK ON ANY NEIGHBOURS THAT MIGHT BE IN NEED OF HELP**
- **MAKE SURE TO WRAP UP WARM**
- **USE TORCHES, RATHER THAN CANDLES, FOR LIGHT DURING THE POWER CUT AS THEY ARE MUCH SAFER.**

Developing weather radars for tomorrow's world



15 OPERATIONAL RADAR PROVIDE COVERAGE OVER MORE THAN **99% OF THE UK**

15 radar sites. A 30-year-old network. One ambitious plan. In 2017 the Met Office's project to renew all the weather radars comes to a close – but the benefits it will bring are only just beginning.

1.5 tonnes of alloy castings have been reused in each new radar...

AVOIDING AROUND **15 TONNES** OF CO_2 EMISSIONS

Each radar makes almost...

1,000,000 ROTATIONS PER YEAR

We can record...

1,800,000 RAINFALL OBSERVATIONS ...PER HOUR, PER RADAR.

Spanning the UK, the Met Office radar network provides real-time precipitation data to forecasters, scientists and a range of organisations. Together with our partners we use that data in two key ways: for monitoring the current weather situation, and forecasting via computer modelling. It's a job the radars have been doing for decades, feeding everything from television reports to weather alerts and helping partners monitor flood risk. But with the advent of new technologies, fresh infrastructure needs and inevitable weathering, it was time for an upgrade. Following an extensive planning phase, 2010 saw the start of a seven-year roll-out.

Driving change

Many of the radar sites date back more than 20 years, so there was a practical reason behind much of the work. "Some of the locations, such as the one up on Stornoway in the Outer Hebrides, mean the radar can get quite weathered," says Richard Bennett, Senior Project Manager at the Met Office. So one of Richard's tasks was to source and manage local suppliers who could lend their expertise to this epic task.

While the main driver for change was to replace an obsolete and increasingly difficult to maintain system, there are a number of spin off benefits associated with the newer technology. "We can now use radar in a larger variety of ways than we originally envisaged, and harness new technologies," Richard explains.

First came Doppler, allowing the radars to observe how the rainfall is moving, and therefore measure the wind as well as the rainfall. Next was dual polarisation. Enabling the radar beams to travel both horizontally and vertically through the atmosphere means that the Met Office can now examine the shape of raindrops. In turn, understanding more about their structure will help forecasters accurately pinpoint the difference between rain, hail and snow. And that means they can provide clearer and more accurate information about heavy rainfall – especially during high-impact weather.

Clearing the way

The twofold introduction of Doppler and dual polarisation is a huge leap forward. Not only will the enhanced network enable the Met Office – and our customers – to benefit in current weather events, it will also help with improving the quality of short period forecasting with an unprecedented quantity of information being returned by the radar. "Because we scan so close to the horizon, we had occasional problems with the beam deflecting off 'ground clutter', such as hills giving us what we call spurious returns," explains Richard. But now, the radar visuals can be cleaned up for a more realistic picture of what's happening. Ultimately, this clearer, more accurate real-time information will have an impact on short period forecasting such as weather and flood warnings, benefitting everyone who relies on the rainfall information the network produces, including the general public.

Efficient, effective and at the cutting-edge

At a practical level, the radars will also operate more resourcefully than before, leading to less call-outs and downtime. And the Met Office sees those efficiencies extending long into the future. "We've developed and deployed a system ourselves rather than using something off-the-shelf," says Richard. "That gives us the flexibility to develop it even more as the network grows." Future-proofing has been front of mind throughout the project. These state-of-the-art systems should equip the radar network for at least the next 10-15 years.

Now that the project is coming to a close – with the last few upgraded radar sites due to be up and running again shortly – Richard is reflecting on a job well done: "Looking back, it's been a real team effort. As we've switched one enhanced radar back on, we've been testing another and starting the upgrade on the next one. But we've had the support of a range of local suppliers, and the Environment Agency which co-funded the project. It's good to celebrate what we've achieved together – and personally, to witness progress happening has been a great feeling."

Met Office | Environment Agency

Planning ahead by working together

The radars and the information they can now deliver are of vital importance to the Environment Agency which co-funded this project.

"For the Environment Agency, a clear, timely picture of weather behaviour is crucial for mapping rainfall rates and locations, then forecasting potential flood impacts on communities downstream so that people and responders can take action to save lives and livelihoods," said Liz Anspoks from the Environment Agency.

Enhanced real-time data, thanks to dual polarisation in particular, will bring huge benefits to the Met Office too – supporting decision-making and potentially improving the speed at which we can get alerts out in extreme weather.

Watch a time-lapse video of the High Moorsley radar installation on the Met Office YouTube channel.

The smallest echo detected is about...

...THAN THE OUTGOING SIGNAL

Our new dual-polarisation radars...

...CAN DISCRIMINATE BETWEEN RAIN, SNOW AND HAIL AND PROVIDE IMPROVED RAINFALL ESTIMATES.

Our new radars have a lifetime of around...

25 YEARS

Winds of change in Myanmar

The Met Office is playing a key role in a project funded by the World Bank that will help Myanmar modernise its observation and forecasting systems.

In Myanmar, around 40% of the population and one quarter of the land area is exposed to flood risk. Yet climate observation and forecasting is really just in its infancy across the country. Myanmar is 2.5 times the size of the UK, but it has just 60 or so weather stations in comparison to our 200 synoptic weather stations and around 4,000 rainfall stations.

The landscape in Myanmar is changing with the first civilian government for decades. New investment is coming into the country and the World Bank has set up a programme to develop infrastructure and capabilities.

The Ayeyarwady Integrated River Basin Management Plan is providing a loan to improve water resources management, modernise meteorological and hydrological services and improve navigation on the Ayeyarwady, the country's most important waterway.

The Met Office's International Development team is assisting with the second part of this vital project, working closely with Myanmar's Department of Meteorology and Hydrology (DMH) to introduce better forecasting, which could have a hugely positive impact to people's livelihoods and the economy.

The project is being led by Steven Wade, Head of Scientific Consultancy at the Met Office. "There's a lot to do to improve all the observations and day to day operations," explains Steven. "We're involved in helping to develop the staff and skills training, advising on the equipment they need, helping the DMH improve flood forecasting and warning and drought advisory services for agriculture."

The Met Office has committed to five months of support a year, for at least two years. To begin with, Steven's role was more along the lines of management consultancy, for instance advising on how to deal with World Bank procedures. However, the role also requires scientific consultancy, and Steven has provided advice on how to measure river flows, and is helping the DMH evaluate tenders for new weather and river flow observation systems.

As Myanmar has little experience of a modernised weather observation system, part of Steven's remit is to encourage the DMH to understand just what is possible. By developing a clear long term strategy, the DMH can grow at a steady pace and manage development as it happens.

Lifesaving progress

The project could make a huge difference to Myanmar. Millions of people rely on the Ayeyarwady River for trade and transport. Floods and droughts have a hugely detrimental effect on people's livelihoods, particularly in the poorest rural communities. By enabling effective observation and forecasting, floods can be predicted and rural communities protected.

The project will also enable the DMH to promote 'climate smart' agriculture. With a better network and improved modelling tools, the DMH and Ministry of Agriculture can advise farmers on how to manage pests and diseases, and even help them decide on the best times to sow, irrigate and harvest. The average losses to flooding are estimated to be $2 billion a year, so timely advice could have a huge impact on the economy.

The project could save countless lives too. Twelve years ago, tropical cyclone Nargis tore through the country, causing catastrophic destruction and leaving at least 138,000 people dead. During the recent tropical cyclone Komen, better forecasting with the support of international partners led to the evacuation of 1.7 million people. There was a much lower loss of life, and just 39 fatalities directly related to Komen.

Global phenomena like cyclones need global solutions. To enhance the work on forecasting in Myanmar, Steven is also linking up with global and regional forecasting centres in India and China. "We're looking at how we can work together to help Myanmar, while not duplicating work," explains Steven.

So far Steven's time in Myanmar has been extremely rewarding, partly due to the work and partly to the location itself, as he explains. "It's a beautiful country at an interesting point of development."

Science profile

The Met Office employs professionals and experts who are constantly expanding the boundaries of weather and climate prediction. Here we meet one of them...

Dr Steven Wade

Head of Scientific Consultancy

Dr Steven Wade is the Head of the Met Office's Scientific Consultancy, leading business development and delivering consultancy projects for private sector and government clients.

The science of consultancy

With the challenges of climate change, business and governments around the world are looking for expertise and advice to help them manage the risks. The Met Office Scientific Consultancy was set up in 2014 to harness Met Office research and deliver knowledge to clients both in the UK and abroad.

The consultancy is headed up by Dr Steven Wade, an expert in water resources with a wide range of experience in environmental science and flood risk management. Before joining the Met Office, Steven worked for a private research organisation, working on a range of projects such as the UK Climate Change Risk Assessment.

When Steven heard about the new consultancy, he jumped at the chance to be involved. "The role was the perfect fit for me," he explains. "All of my consultancy work was related to climate, so I didn't hesitate to apply for the job at the Met Office when the right role was advertised."

On joining, Steven's first task was to build up the Scientific Consultancy team, while also tendering for consultancy projects and delivering to external customers. The team brings together experts from different sectors such as marine and hydrology, and can also draw on wider expertise within Applied Science.

The mixture of disciplines and expertise is one of the most satisfying parts of the job for Steven. "In my previous role I was the main climate change expert in the company," he explains, "but now I'm working for the Met Office I can be one of several hundred experts. I get to explore things in more detail and have access to the latest science."

Varied work

The team works on a huge range of projects, including everything from modelling marine conditions to developing future 'what if' scenarios for the UK Climate Change Committee. "We have now completed a large number projects to help customers understand climate risks and to ensure their future plans are resilient to extreme floods, droughts and warmer conditions."

"Now I'm working for the Met Office I can be one of several hundred experts. I get to explore things in more detail and have access to the latest science."

The consultancy's work is also gaining an international dimension, as several international projects have landed in Steven's in-tray. There's a huge demand for climate expertise to reduce the damage and losses of disasters. As such, Steven's role comes with a lot of work overseas.

"To make progress you really need to be working alongside the teams based in the developing country," explains Steven. "You can only make so much progress working remotely."

Steven is currently spending a lot of his time in Myanmar, as part of a World Bank programme to help their meteorology experts develop the country's observations and forecasting systems. While Steven gets to indulge his passion for hydrological fieldwork on the Ayeyarwady River, most of the project involves working with partners in Myanmar, offering management support and guiding the programme forward.

"The balance of UK and international work is a great part of the job – it is good to travel and work with lots of different people," he enthuses. "It is also good to continue my UK research and consultancy in the water sector." Steven is working with UK universities on water resources research and was recently appointed as an Independent Environment Advisor for Severn Trent Water's Water Forum.

STEM at high altitude

Many Met Office staff take part in Science, Technology, Engineering and Mathematics (STEM) activities at sea-level, whether it's at Met Office Science Camp or other events. But when Hamish Steptoe, Applied Climate Scientist, had the opportunity to join an expedition to the Indian Himalayas, he jumped at the chance. Here Hamish describes the highs and lows of delivering STEM activities at an average height of 4,500 m above sea-level.

The British Exploring Society is a charity providing personal development opportunities to young people aged 16-25 from a diverse range of backgrounds. The organisation runs five-week expeditions to remote, wilderness environments, inspiring young people to develop confidence, teamwork, leadership and spirit of adventure, and help them better understand the world around us. An integral part of this is scientific investigation so the society carries out expedition projects.

As Science Leader on this summer's expedition to a remote part of the Zanskar Valley in Ladakh, India, my role was to engage young explorers (YEs) in meteorology and encourage them to ask questions relating to the environments and processes they were seeing. To avoid limiting activities to particular age groups, I planned projects with work accessible at different levels. With help from the University of Reading, I took a variety of mounted and hand-held instrumentation which helped introduce basic concepts of meteorological observing.

Stepping outside the classroom

At 4,500 m, simply walking up the moderate 10 m incline to the met-station required a few minutes rest to catch my breath. Daily challenges – sleeping in tents, eating ration packs and long days outdoors – meant that encouraging YEs to engage in science during early mornings or late evenings was really demanding.

However, when we started taking basic observations, the YEs quickly realised the importance of understanding and predicting the weather in an expedition environment – from choosing clothes for the day to planning routes to a nearby peak.

Stepping outside of the classroom gives an immediate relevance to the science you are teaching. Even 7.30am sessions were surprisingly popular given the time of day, and the handheld instruments gave the benefit of providing real-time information. A forecasting guide I prepared gave students an opportunity to take things further and make basic forecasts of daily minimum and maximum temperatures, calculate wind chill, heat stress, and cloud-base height.

Expect the unexpected

Planning and preparation is essential for expeditions, but some things you just can't foresee. Half-way through the expedition, when most people were comfortable with the daily routine, a Himalayan Brown Bear entered our camp. After a few nights, the bear broke into tents to find food. Eventually we had to relocate our camp, and activities were delayed by a week. Such is expedition life.

As Naomi Holmes, Chief Scientist on the India Expedition put it: "Expeditions never go exactly to plan, and this was the case for the 2016 British Exploring Himalaya expedition. The environment was challenging and it was necessary to change the original plans. Despite this the scientific programme was successful with lots of young people engaging with a variety of scientific ideas and techniques. Since the expedition many of them have continued to pursue scientific interests."

A youth expedition to a remote part of northern India was not restful but the rewards were huge. As a personal development opportunity, giving me the chance to expand my leadership experience, develop and deliver my own science plan and enthuse a range of young people about weather and climate science, it was incredibly rewarding to see the development of the YEs throughout the trip. Despite the challenges, for YEs this was a chance to see what meteorology can do for them, and understand how weather and climate impacts all our lives.

Enjoying the highs and lows of organic gardening

Come rain or shine. Through warm winters and cool summers. For River Cottage's Head Gardener **Will Livingston**, growing organically is all about nurturing the soil and adapting to whatever the changing weather and climate has in store.

Born into a farming community in rural Devon, Will first discovered his talent for gardening on his family's allotment. Then in 2008, after studying Countryside Management at agricultural college, a friend introduced him to Hugh Fearnley-Whittingstall at his famous organic smallholding in Axminster – River Cottage.

Will started helping out on the 90 acres of farmland, paddocks and grazing pasture. Then after taking some RHS courses to hone his horticultural skills, he was over the moon at being made Head Gardener of the semi-formal Victorian kitchen garden at River Cottage and the 1.5 acres they use for growing fruit and veg.

Growing ups and downs

In the last ten years, Will has detected a shift in seasonal temperatures and a change in normal growing patterns. While fewer cold, hard winters have meant planting often starts earlier, bacterial and fungal diseases are not getting killed off as quickly.

"The torrential rain of 2012 ruined a lot of farmers, yet this year's summer was fantastic and gave us an incredible harvest of tomatoes, aubergines, lettuces, herbs and chillies."

Tradition meets innovation

As an organic grower, Will encourages symbiosis between the cultivated and wild. He mixes plants such as borage, calendula, and french marigold among the crops in the 50-foot long polytunnels. "I then just leave the doors open for bees to pollinate the Mediterranean veg, while the wild flowers deter the whitefly," he says.

He also prefers to control problems like slugs and snails naturally – tempting them into his 'slug pubs' made from jam jars filled with beer, part-buried in the soil. Will believes, however, the long-term solution should not be stopping the pests, as much as keeping plants strong and healthy – as they'll then recover from being nibbled at more easily.

His personal views on climate change are equally pragmatic. "It's pretty complex –but being such a gradual progression, our growing methods tend to evolve with it." Interestingly, River Cottage has trialled the latest niche of 'climate change gardening' – when exotic specimens such as the Japanese Wineberry, pecans, olives, ginger and turmeric are successfully grown outdoors in the UK.

Making less impact

Will wholeheartedly shares Hugh Fearnley-Whittingstall's environmental principles. And in keeping with the 'nose to tail' philosophy River Cottage has for meat, Will takes a 'seed to plate' approach for crops. Raw veg rubbish goes into compost bins or is fed to the chickens and pigs. While cooked food scraps are bio-gas digested for energy. Being a zero-landfill site, the farm also uses a biomass burner, wind turbine and rain water collection tanks.

"This year's summer was fantastic and gave us an incredible harvest of tomatoes, aubergines, lettuces, herbs and chillies."

Will also doesn't rely on frequent rainfall as much as some non-organic farmers do. Instead, he recommends digging in plenty of organic matter. So, even during dry periods, there's enough residual water for the plants. As he says, "You can't control the weather, but you can control the quality of your soil."

For Will, taking the rough with the smooth is just part of the job. "When it's a wet January, your boots are clagged with mud and you're doing a lot, but achieving very little – that can be a bit depressing. But the beautiful summer mornings more than make up for it. And raising something from seed into delicious food and inspiring people who come to my classes to grow their own fruit and veg – you can't beat that feeling of satisfaction."

Attention all shipping

Oxfordshire artist Jane Tomlinson has won a prize for her original painting of a map of the shipping forecast, the much-loved daily weather report produced by the Met Office on behalf of the Maritime and Coastguard Agency.

The British Cartographic Society, which champions the art and science of mapmaking throughout the world, awarded the John C Bartholomew Award for Thematic Mapping to Jane at its annual conference earlier this year.

Explaining her inspiration for the painting Jane said, "I've always loved the stark factual poetry of the broadcast, and since I painted this map I've discovered that the shipping forecast seems to be embedded in the DNA of every Brit. It's a part of who we are – weather-obsessed, word-loving islanders. I wanted to capture the spirit of the shipping forecast and record all those magical words in their rough geographical position."

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