Met Office

Barometer

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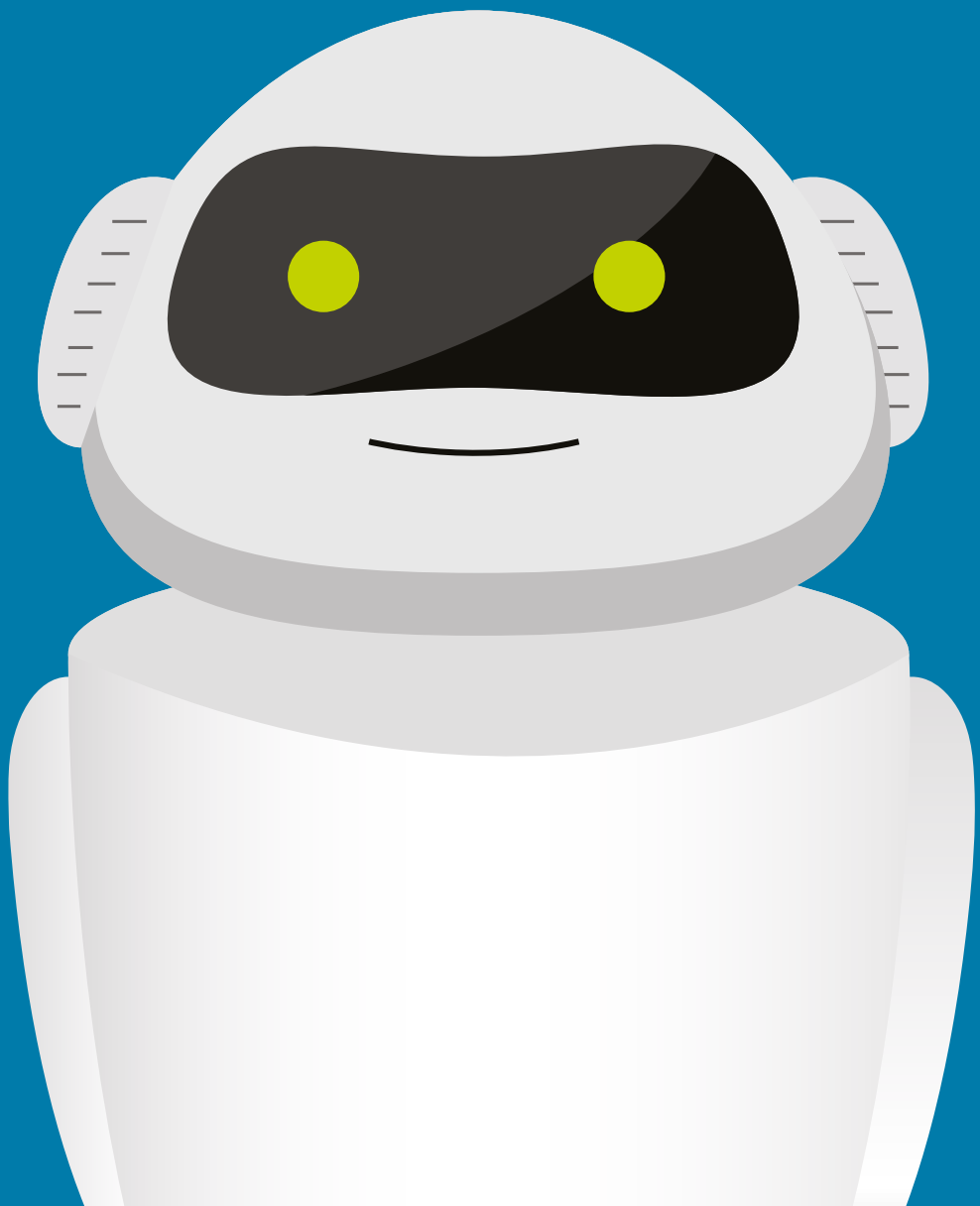

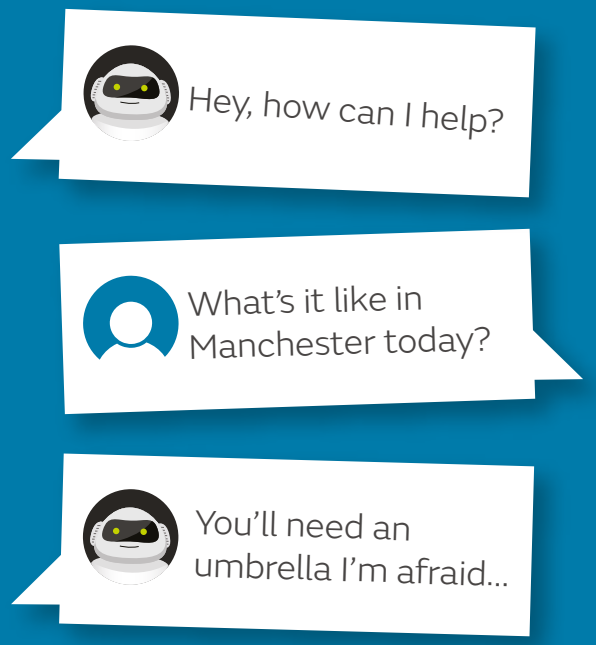

Natural language interfaces

New ways of delivering forecasts

Across its wide spectrum of services, the Met Office continues to generate value for money for businesses and administrations across the world. ***Director of Government Services Andy Kirkman*** introduces some of the cost efficiencies and economies highlighted in this edition of Barometer.

Forecasting value

I'm delighted to be introducing the latest issue of Barometer. As Director of Government Services, I'm very much aware of the broad remit of our work and the different agencies we serve. The sheer variety of work in this latest edition is a testament to the portfolio of valuable services we offer our clients.

One thing that makes the Met Office different is that we offer an end-to-end service, from observation right through to delivery and communication. We don't just have the technology, but we understand what the impact of our findings can be. That makes us truly unique as a government agency, and I know it's something that our partners really value.

In fact, a recent review process with the UK Government showed that we provide the nation with £30bn of economic value over a 10-year period. That's a 14-to-one return on investment.

To take just one example of that value in practical terms, we had excellent feedback from both the Scottish and Northern Irish governments, specifically on the granularity and accuracy of the information we provided during the storm brought to us by ex-hurricane Ophelia.

The Scottish administration was able to use our forecasts to measure how the new Queensferry bridge crossing responded to the storm, to influence any future fine-tuning. The fact that governments, administrations and agencies can use our work in this way to inform investment in local infrastructure shows the unique value of the work we do.

The work we do often pays dividends in the years ahead. For instance, as part of the National Flood Resilience Review, the Government asked the Met Office to evaluate the likelihood of a worst-case scenario for extreme rainfall over the next 10 years (page 19). A new method means that we can now provide more precise estimates for a one-in-100, or one-in-20 scenario. This information is vitally important for building future flood defences.

In the retail sector, we are collaborating with Marks & Spencer, helping them to plan to make their supply chain more efficient and reduce the amount of food they have to throw away (page 13).Another example is our recent work with the Ordnance Survey to create a 3D model for 5G services (page 7). The work could enable future 5G service providers to pinpoint optimum sites for antennae to roll out networks in the most efficient way possible.

Our work isn't just limited to the UK, and on page 17 of this edition you can read about our how we are helping to predict outbreaks of wheat viruses in Ethiopia. The project could protect crops and save large sums of money as farmers can take action to prevent any wastage of crop spray.

Back in the UK, it was recently the 30th year since the Great Storm of 1987. The timing was immaculate, as ex-hurricane Ophelia battered our northern coasts at the very same time. Our understanding of storms like this and the way we communicate them to the relevant authorities are so much more advanced than they were just 10 years ago. You can find out more in our article on the anniversary of the Great Storm on page 9.

Investment and improvements since the Great Storm mean that we are now much better prepared to forecast and warn people of potential impacts from storms. We continue to push ourselves to provide more value to our customers, and you can read about a range of enhancements we are making to the National Severe Weather Warning Service (NSWWS) on page 3.

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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.

Learn About Weather

Blending the public's interest in weather and climate with the learning resources of the Met Office, we have developed has led to an exciting, new course for the general public; Learn About Weather.

Learn About Weather launched in September, attracting over 10,000 people with an interactive, four-week online course, free at the point of use for the general public.

Senior Operational Meteorologist and Learning Consultant, Helen Roberts said: "The course provides accessible education on weather and climate, and requires no prior knowledge, just a curiosity about the weather."

We worked with the University of Exeter and Royal Meteorological Society to develop the course, the Royal Horticultural Society on some of the gardening focused learning, and the Royal Photographic Society for some of the photography content.

Running over four weeks, the course involves just a few hours of learning each week. Weeks one to three cover the basics of weather, including before moving on to synoptic charts, air masses, fronts, wind and clouds. Week four focuses on leisure activities that are affected by the weather. This involves putting knowledge into practice, with specialist advice for gardeners, photographers and walkers. There's something in there for everyone, so why not sign up yourself?

To find out more visit: www.futurelearn.com/courses/learn-about-weather

Harnessing the power of forecasts

You will be familiar with checking the weather forecast before planning a day out. Now you can check the forecast to find out the greenest time to put your washing machine on.

Using Met Office data, the National Grid, in cooperation with the Environmental Defence Fund Europe (EDF) and WWF, has launched a forecast enabling the public and businesses to better understand and plan their energy use.

Using weather data from the Met Office and combining it with data from the grid, National Grid can forecast demand for electricity and identify the renewable energy flowing into the grid. Using this information, they can forecast the carbon output of the grid over a 48-hour period, and identify the periods of lowest carbon output and highest carbon output. In other words, how green the grid will be during that period.

Partners involved in the project hope consumers will be able to plan their electricity use around periods of high availability of renewable energy, reducing carbon output.

Patrick Sachon, Met Office Business Group Leader for Energy said: "The green energy forecast is a great example of innovative re-use of Met Office data. As a scientific organisation we encourage the re-use of our data, particularly if it can be applied to develop a deeper understanding of the interrelation between weather and something that is so integral to our everyday lives such energy."

Enhancing the National Severe Weather Warning Service

Following extensive user research, we are making a range of improvements to the National Severe Weather Warning Service (NSWWS).

The NSWWS 'Next Generation' project is looking at the way we produce warnings, the way we communicate warnings, and how people experience and access our warnings.

A key part of the project is improving how we communicate the risk of severe weather. We are making changes on all our channels, including our website and app, to the visual design of warnings and the language we use to describe severe weather and its impacts. We aim to make use of additional content to help our audience understand the forecast and what they can do to keep themselves and their property safe. Another target is to be able to issue warnings much faster when the weather is changing rapidly.

We will also be introducing additional warning types for thunderstorms and lightning and extending warnings from five days out to seven days.

Mel Harrowsmith, Met Office Head of Civil Contingencies said: "One of our key priorities is to continuously evolve and improve the quality and delivery of Met Office weather warnings, as they are essential for protecting life and property in the UK. Many of you will have already seen some of the changes to the look and feel of warnings on our website and app, reflecting the findings from our user research. More changes will be made over the next few months, which will see project complete in spring 2018."

A natural phenomenon

The Met Office is using natural language interfaces to create new ways of delivering weather forecasts.

From newspapers to radio, from television to smartphones, the Met Office has always embraced the latest media when delivering forecasts. Now our developers are focusing on natural language interfaces to deliver forecasts via Amazon Alexa and a 'weatherbot' on the Met Office Facebook page.

"Natural language interfaces let you interact with a system with humanistic speech or text," explains Thomas Powell, Met Office Informatics Lab Technologist. "So you can ask literal questions and receive an understandable answer."

The technology was developed as a pilot by Thomas and his colleague Niall Robinson. The Met Office Informatics Lab worked closely with Amazon to include a weather update as part of the daily briefing that Alexa delivers to users in the home. Similar technology sits behind the weatherbot, which enables users to ask questions like, "Do I need to take an umbrella?"

Tomorrow's world

Although devices like Alexa aren't yet in every home, Chris Frost, Head of Digital at the Met Office, believes there will be a huge uptake in the technology.

"As children grow up with devices like Alexa, it will be second nature for them to control objects by talking to them," says Chris. "Like telling the light bulbs to dim or turning the TV on or off."

The Met Office is determined to be at the forefront of the latest developments, making weather forecasting available to people however they wish to access it.

As Chris says, it delivers directly to their remit of working together for protection, prosperity and wellbeing: "We're saying the right thing at the right time, to the right audience, so that people can take action to stay safe."

A question of working smarter

Natural language interfaces could transform the way we work at the Met Office. Our systems hold a vast amount of data, so accessing and interrogating it can be a complex process. Scientists have to become familiar with data language and code, and request information from colleagues. So imagine if someone can call up data simply by asking a natural question like "What's the rainfall data for Beijing this year?"

"If someone comes straight from a physics degree, they're not going to know all of our internal storage systems," explains Thomas Powell. "But if they can get the data they need and concentrate on the science part, it could really free them up to focus on what they do."

To take another example, journalists often pose the Met Office questions like, "Is this the wettest day of the year?" With a natural language interface in place, the engine could crunch the numbers and come back with an answer in super-fast time. It could change the way all of us work.

Lessons and legacy

As we looked back at the Great Storm of 1987 in October, it was perhaps fitting that ex-hurricane Ophelia made her presence felt. Our accurate forecast and warnings underlined just how far things have come.

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October marked the 30th anniversary of the Great Storm of 1987. Forecasters at the time had been predicting severe weather up to four days ahead. However, as time went by, weather prediction models were unclear, suggesting severe weather would pass south of England, only brushing the south coast.

Although our autumnal storms usually come from the Atlantic and the west, this storm developed over the Bay of Biscay to the south. Many of us remember the words of Michael Fish before the storm struck: '...earlier on today apparently, a woman rang the BBC and said she'd heard there was a hurricane on the way. Well, if you are watching, don't worry, there isn't...'

The Great Storm

He was talking about a different storm in the North Atlantic. He said it wouldn't reach the UK, and it didn't. However, the storm from the Bay of Biscay did. It wasn't a hurricane as they need specific conditions found in the tropics. Even so, there were hurricane force winds in some parts of the UK during the Great Storm.

Arriving over the south coast of the UK, the storm tracked north and east before reaching the Humber estuary at about 5.30am on 16 October. This path crossed a densely populated area of the UK, intensifying the damage. The worst damage occurred in southeast England, with gusts of 80mph for three to four consecutive hours. Gusts of more than 100mph were recorded at several coastal locations.

The Met Office and other European forecasters had failed as forecasting capabilities at the time just couldn't always predict the intensity of this type of storm. This failure became the catalyst for a programme of investment and improvement in the science, technology and communication of forecasting, which has transformed the way the UK responds to severe weather.

Ready to weather the storm

The Met Office now works with other leading international research centres, pushing to for ever-better accuracy. This helped by improved observations from satellite data and deep ocean weather buoys located around the British Isles, providing hourly weather information and helping us to monitor developing weather conditions.

Supercomputing capability has also advanced since 1987. A typical smartphone of today has a least five times more computer power than our supercomputer of 1987 that could perform 4 million calculations per second. Today our latest supercomputer is able to perform 14,000 trillion calculations per second helping us to unlock new science and provide more detailed forecasts and warnings.

We're now much better prepared to forecast storms and warn people of potential impacts from storms. After the Great Storm of 1987, the Met Office set up the National Severe Weather Warning Service (NSWWS) to deliver warnings to the government, emergency responders and the public.

Ex-hurricane Ophelia

In October this year, as we remembered the Great Storm, stormy conditions were arriving in Ireland and western parts of the UK in the form of ex-hurricane Ophelia. Although Ophelia brought impactful weather to many northern and western parts of the UK, other areas – such as South East England – had warm and mainly dry conditions. Temperatures were well above the average maximum temperature due, in part, to ex-Ophelia bringing warm air from Spain on its eastern flank.

Advances in forecasting meant that we were able to provide medium-range guidance on 11 October, well in advance of any impacts, identifying ex-hurricane Ophelia as likely to affect parts of the UK on 16 October. Over the following days, we worked closely with Met Éireann, the Irish meteorological service and the National Hurricane Center in the US.

Ireland took the brunt of the storm with hurricane force winds of up to 80mph across Northern Ireland. Some areas bordering the Irish Sea saw some travel disruption, power cuts and damage to buildings. National Severe Weather Warnings for Northern Ireland, and other western and northern parts of Britain helped people take the necessary precautions to keep safe.

There is no doubt that the Great Storm of October 1987 remains one of the most influential weather events for a generation. Improvements since 1987, resulting in our world-leading weather forecasts, and accurate forecasts of ex-hurricane Ophelia, are all part of our continuing effort to provide ever better guidance. The Great Storm will continue to drive us in the future as we do our utmost to improve our science, technology and the way we communicate even further.

An interesting aspect as a result of the movement of ex-Ophelia was the colour of the sky and the sun, and dust on cars. Southerly winds brought dust from the Sahara and particles from wildfires in Portugal to our latitudes. Dust scatters the blue light from the sun, letting more red light through much as at sunrise or sunset giving a strange orangey-red light.

Be sure to check out our other storm article:
→ Royal Charter Storm (page 21)

Hurricane support

During September 2017, we provided advice to UK Government in response to the run of damaging Atlantic hurricanes, including Harvey, Irma, Jose and Maria in the Caribbean.

This included Met Office staff attending the government emergency committee (COBR), providing specific briefs to the Foreign Office, the Department for International Development, and also supporting the emergency response work of the armed forces.

Internationally, we worked closely with our colleagues in the United States National Weather Service (NWS) sharing output from experimental versions of our convective scale and coupled ocean and atmospheric models that our science teams configured in a remarkably short space of time. This provided another important source of reference for both the Met Office and the United States NWS forecasting teams.

Although the Hurricane Crisis had devastating impacts, early warning support helped to protect lives in the Caribbean and southern US states by providing invaluable guidance to decision makers.

It's all in the networking

The Met Office was recently part of a ground-breaking team delivering an important part of the industrial strategy – by shaping the next generation of mobile communications.

From the Internet of Things to smart cities, the move to 5G technology promises to have a huge impact on the world around us, bringing internet-connected devices into everyday life. But before investing in new networks, 5G providers want to be sure that the infrastructure is as robust as necessary to meet users' needs. Not only that, as their investment could run into billions of pounds, they want to prevent any unnecessary overspend too.

That means understanding how to meet two fundamental challenges that are part and parcel of 5G. As the network will run at increasingly higher frequencies than the current 4G bands, signals will be much less able to 'bend' around obstacles such as hills, buildings or even bus shelters. Consequently, technology will rely on direct line of sight between radio antennae. A highly accurate 3D model of the urban landscape is therefore needed to optimally place 5G assets. Secondly, weather will have an impact on network performance, as raindrops can degrade signal strength, so it is critical to understand the degree to which the day-to-day variability of UK weather, including extremes, must be designed into the future networks.

To understand more about these challenges, a team of experts, led by the Ordnance Survey, was brought together to create detailed 3D modelling of a cityscape. The team included the Met Office and the 5G Innovation Centre (5GIC) based at the University of Surrey in Guildford.

Getting the full picture

The project concentrated on Bournemouth, with Ordnance Survey building a 'digital twin' of the area to a 10 cm granularity. The Met Office team was led by Dave Jones, Head of Observations Research and Development.

"The project just happened to be looking at the frequency band that I studied for my PhD, so it was very exciting to work on it," explains Dave.

The Met Office already had a lot of the science in place to model rainfall distributions and understand their impact on 5G frequencies. To make the model as realistic as possible, Dave's team used real weather scenarios from the Met Office weather radar archive, focusing on high profile events such as Storm Angus from November 2016. Archive data was available at a spatial granularity of 2 km, but the team used a technique known as downscaling to represent how rainfall varies on a scale of 100 m, which is representative of the sorts of antenna separations we might expect for 5G.

The work highlighted two likely worst-case scenarios for 5G: summer convective downpours and frontal conditions with temperatures just above freezing, where rainfall might arrive at ground in the form of melting snow. Both instances could severely affect signal strength, depending on the frequency bands that are eventually selected.

> *"The project just happened to be looking at the frequency band that I studied for my PhD, so it was very exciting to work on it."*

Knowing the details of how weather affects the signals, providers will need to weigh up cost versus availability.

"The rainfall events will reduce the capacity of the network, but do we need a network to be working at full capacity when there's a downpour? Will people be streaming video outside in the pouring rain?" explains Dave.

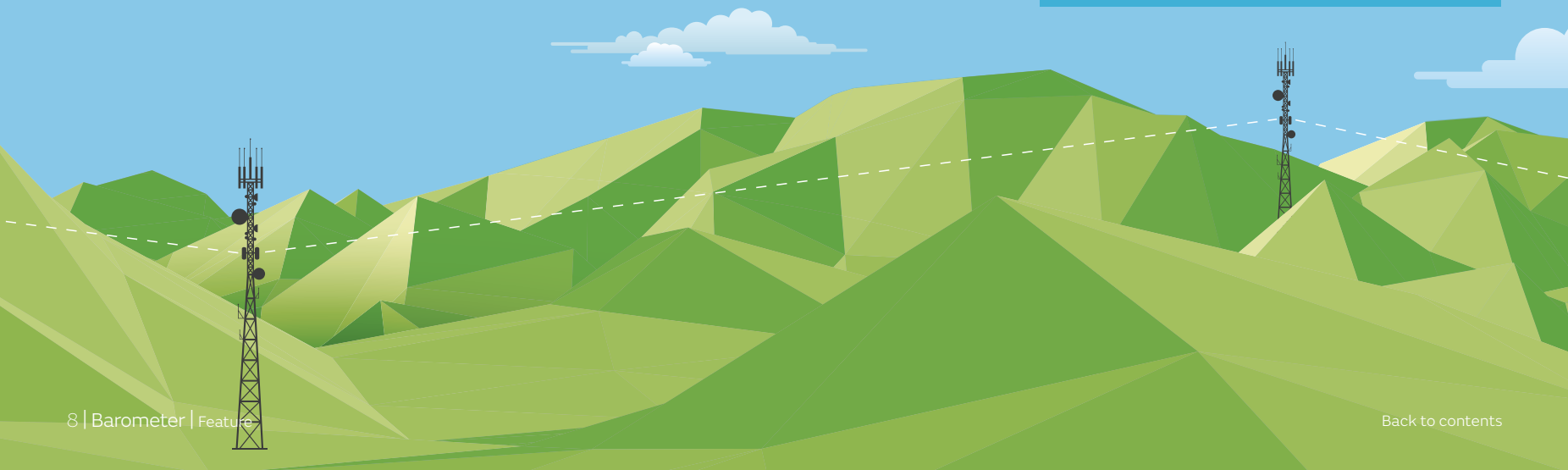
The work is extremely important for UK businesses as 5G could well transform people's day-to-day lives. From augmented reality to autonomous cars, lots of technology will rely on the connectivity that 5G will unleash. The Met Office's involvement in the project will contribute to optimum investment in the networks.

The project is an excellent example of the Met Office working in close collaboration with other leading organisations, including the Ordnance Survey and 5GIC. "Working together with subject experts from different fields was really rewarding," says Dave. "It was good to work with such a focused team."

From signal to forecast

5G communications is going to be part of the crucial infrastructure for the UK and the Met Office is keen to play a part in that. However, there's one other possibility that the link between 5G and rainfall opens up. Because we know that rainfall affects signal strength, then we can turn that around and use real-time 5G signal strength to tell us about rainfall rates as it is falling.

"People have already been trying this with 4G, particularly in the Netherlands," explains Dave Jones, Met Office Head of Observations Research and Development. The technology will never replace the Met Office's rainfall radar network, but the readings could complement the Met Office's existing observations networks to give an even greater level of detail on surface rainfall in urban areas. This is just one several possible opportunistic observations that the Met Office is exploring to improve our understanding of the state of the atmosphere from infrastructure that was originally designed for other purposes.



Keeping our weather stations afloat

To predict the weather tomorrow, next week or further ahead, you first need an accurate picture of what it's doing now. This is why the Met Office has a network of Automatic Weather Stations (AWS) that send observations of conditions around the UK and at sea. While these stations may be automated, keeping them up and running is down to the work of dedicated engineers such as James Eustice.

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James has worked for the Met Office as a Marine Systems Engineer for the past three years, specialising in electrical engineering. He helps with maintaining the Marine Observing Network, which includes weather observation units on board ships, weather buoys and permanently moored light vessels.

The variety of the work, as well as the chance to get to grips with all sorts of technical problem-solving, is what attracted him to the role. "I might be in the workshop repairing equipment, going out to sea to deploy it or designing new systems. There's quite often something different to do."

All at sea

As the ocean can have such a strong effect on the atmosphere and, in turn, the weather, the observations taken by the Marine Observing Network are vital for climate and weather models. Maintaining each type of station comes with its own set of challenges for James and the marine engineering team.

Weather buoys, for example, are securely moored in the deep waters of the North Atlantic. The sensors on board measure the air and water, sending observations including temperatures for both, wind speed and wave height to the Met Office every hour. Every two years they need servicing to make sure they're in good working order.

As they stand at 6 m tall and weigh over 4.5 tonnes, a crane is needed to bring them onto the boat and back to a dock – either Southampton or a partner site around the UK. Once there, James and the team take them apart, replace the sensors and rebuild everything. "They can take quite a lot of weather damage," James explains. "For example, the solar panels might get ripped off by the wind." James often takes a couple of sea trips a year to help with redeploying the buoys, making sure they're secured in the right position and that all the electrics are up and running.

> *"With so many marine weather stations in difficult to reach locations, what happens if they stop working?"*

Maintaining ship-based AWS and light vessels – permanently moored boats which also carry light beacons to help ships navigate busy waters – means going out in a workboat, boarding the vessel and replacing equipment on board. James works with port-based Met Office staff and organisations such as Trinity House, which maintains light beacons, to make any repairs that are needed.

Planning around puffins

As well as the buoys and light vessels, the AWS network includes a land-based station on Sule Skerry – a remote island 40 km west of Orkney in the far north of Scotland. James and the engineering team visit this station once a year to update the equipment and change the sensors. It's a trip that requires careful preparation – partly because there's only a brief window of time the island can be accessed. "There's a huge population of puffins on Skerry," explains James. "We can only visit in autumn once the breeding season is over, and before the winter weather gets too bad."

Skerry is so remote that it can only be reached by helicopter. "Once we're there we have five or six hours to finish our work – it's the sort of trip where you want to be sure you've got everything you need with you, as you can't go back until next year!" says James.

With so many marine weather stations in difficult to reach locations, what happens if they stop working? "There are two stations on board every light vessel and buoy," James explains. "So if one fails there's always a back-up."

Designs for the future

As well as maintaining the current network, James is involved with designing new equipment such as the AMOS2, next-generation weather buoys that will be deployed from 2018.

James explains that, although the current electronics have been reliable, enabling the AWS network to transmit weather observations for decades, recent technological advances mean there's a chance to add more capabilities to the buoys. "We're incorporating remote connectivity," says James. "The current buoys send observations every hour, but with the AMOS2 you could make ones in specific locations send them more frequently, just by emailing them."

Systems such as this don't come off-the-shelf. James has been working with specialist companies including Campbell Scientific to design custom elements. These range from connectors that are small and robust enough to stand up to the harsh weather conditions of the North Atlantic, to custom wire looms that will make sure every part of the AWS is connected efficiently and securely.

James is looking forward to seeing the AMOS2 deployed. "I've really enjoyed the development work we've been doing. And it's always rewarding to design something and then see the finished product. You get a great sense of satisfaction from that."

Met Office | M&S

A collaborative way of working

The weather has a big influence on people's daily activities – from what they wear and how they travel, to the food they buy. So for retailers, having accurate information is vital to help them meet their customers' needs. Our Expert Partners campaign is shining a light on how the Met Office is working with companies including Marks & Spencer to create bespoke weather services that keep them a step ahead of customer demand.

With online shopping and ever-more options on the high street, customers expect to be able to buy exactly what they want, when they want. While the average consumer might not be aware of how the weather influences their choices, retailers like M&S know all too well about the huge impact it can have on their sales. As vast supply chains sit behind every well-stocked shelf, being able to plan ahead is vital for reducing running costs.

"We've been working with M&S for more than three years," says Barbara Napiorkowska, Business Manager for the retail sector at the Met Office. "We felt the Expert Partners campaign was a great opportunity to talk not just about the services we provide them with, but our collaborative way of working with them."

Collaborating to create bespoke services

On the surface, it might seem obvious that customers look for light food in warmer weather and hearty comfort food when it's cold. But are people choosing fresh fruit and salads, or sandwiches? Soups, pasta dishes or pies? What about if it's a warm day, but due to rain later? Or if it's cool now, but there's a heatwave expected at the weekend? When the weather's as changeable as it is in the UK, planning around it starts to look a lot more challenging. For M&S, that means calling on more detailed information than a typical, day-to-day weather forecast.

"Working together with the Met Office, we've created specific models to help us predict and better understand what customers want to buy when the weather changes," explains Andy Bowsher, Central Forecast and Inventory Manager at M&S.

This collaborative process began with Met Office experts talking to M&S to find out more about their decision-making processes, how their supply chains work and what their key business drivers are. As Barbara points out, "It's vital we understand how a business operates, then we can understand how we can work together to provide the most appropriate services for them."

For M&S, this includes a detailed weather briefing integrated into their daily demand planning process. "We start each day with a conference call where Met Office forecasters will talk us through the weather for the next seven days," says Andy from M&S.

> *"Working together with the Met Office, we've created specific models to help us predict and better understand what customers want to buy when the weather changes."*

"We then discuss the likely impact the weather will have on planned product volumes that we already have in the system. This information is vital as it helps us make decisions about varying volumes and making changes to what we place out in stores."

With timely advice, it's possible to make changes to stock orders just one day in advance. Having this collaborative, reactive relationship in place means M&S can make their supply chain more efficient, reduce the amount of food thrown away and make sure customers can easily find the products they want.

Digging deep with data analytics

To build a more detailed picture of how weather influences customer behaviour, we are planning to look at M&S's past sales data, and compare it to weather forecasts to identify any correlation. This will enable us to develop models based on specific parameters relevant to M&S – and introduce new capabilities for M&S – from understanding the effect of sunlight hours on sales, to how rainfall can drive footfall to specific stores.

Having such a close understanding of M&S's needs means that the Met Office is continually looking for ways to improve the services we offer. For example, with supply chains becoming more complex and tied to global issues such as climate change, the Met Office is exploring longer-term forecasts and consultancy services for the retail sector.

As Barbara points out, "Whatever we do, it's all delivered in a collaborative way where we work together with the customer to make sure our services always meet their needs."

Part of some

During the week, Dr Joanne Robbins develops products that forecast the likelihood of high-impact weather events and other natural hazards within the Met Office's Weather Impacts Team. But at the weekend, she might be training to respond to humanitarian emergencies as a volunteer with the charity MapAction. Or even assisting deployed teams for the charity as they support the emergency response to hurricanes, earthquakes and humanitarian crises around the world. As Jo has found, these two parts of life aren't as separate as they may seem.

When disaster strikes, it's essential that national governments and humanitarian agencies have a clear view of the situation on the ground. What has happened and where? How many people have been killed, injured or lost their homes?

This is where MapAction, a charity that produces maps of areas affected by disasters, comes in. A team of volunteers aims to be in the field within 24–48 hours – ready to produce maps that identify the priority needs for the emergency response activity, helping keep every agency involved on the same page.

Jo joined MapAction three years ago, after first hearing about the charity at university, "I was studying geophyscial hazards – then, when I came to the Met Office, I was working on developing risk and impact-based models for different types of severe weather. I'd always been interested in disaster risk reduction and understanding the physical and human aspects of disasters. MapAction's activities on-the-ground, in disaster affected regions, gives a different perspective and is very much a more applied side of that, so it seemed like a natural fit."

Getting field ready

As a charity, MapAction relies on volunteers giving up their time for fairly intensive training to get them ready to support the response on the ground. Once a month, volunteers attend weekend development sessions, focused on essential skills such as using GIS (geographical information systems) to create maps. These maps display specific data depending on what's needed by the government or aid agencies in-country, from where roads have been damaged to the quality of drinking water in the affected area.

Jo says that she enjoys mapping and uses GIS regularly as part of her work at the Met Office. But there was still plenty to learn before she felt ready to go into the field. "Before you deploy, you attend simulation exercises to practice what it will be like," she explains. This is usually a simulated response to a disaster spread over a few of days.

"I'm not from a humanitarian background, so understanding how skills such as mapping work in that context is very different from my day job. Suddenly you have to communicate with all sorts of different people who all need you to produce maps at short notice. The training is really valuable for handling that."

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thing bigger

Mapping the aftermath of the Regent Landslide in Sierra Leone

Jo's first field deployment came in August 2017. Sierra Leone was in the grips of its seasonal monsoon, when heavy downpours caused severe flooding and a large landslide in the capital, Freetown. More than 800 people were killed, and 5,000 people left in need of aid such as food and shelter.

Jo and two other MapAction volunteers went in to support a United Nations Disaster Assessment and Coordination (UNDAC) deployment. Their first task was to help determine the scope of the emergency. This included pulling together information from satellite images of the valley hit by the landslide, identifying areas that could also be vulnerable to flash flooding, and finding out more about how the government was registering affected people.

Pinning down these essential details, Jo explains, means they can identify what the most important needs are – enabling the response to move forward on firm footing. Then it's a case of keeping track of what the response is, to make sure aid is reaching the people who need it most.

"We often produce what's called 4W maps," says Jo. "These identify who's operating in an area (for example the Red Cross, UNICEF), what they're distributing – whether that's food, items such as clothing and bedding, or even psychological support – where they're distributing it and when. This helps us spot where people might be being missed out."

> *"These maps identify who's operating in an area, what they're distributing, where they're distributing it and when."*

MapAction's maps are uploaded to their website and other humanitarian data portals, and can be freely accessed by anyone who needs to use them. Volunteers who aren't on deployment help create and upload these maps from home, using data supplied by their colleagues in the field.

Although MapAction's main role is to respond to emergencies, they also play an important role in preparedness and capacity building. They run training sessions to help local organisations increase their future resilience. This might involve developing their mapping capability or providing training in information management. All delivered by experienced volunteers.

Bringing a new perspective to the day job

Back in the UK, Jo is a Weather Impact Research Scientist at the Met Office. She explains that, while weather forecasts typically communicate the likelihood of heavy rainfall or hurricanes, impact models aim to communicate how that weather event will affect people. This means taking into account the resilience of local infrastructure, as well as factors such as the economic situation, social structure and demography. All of these elements can spell the difference between being able to comfortably weather a storm and move on – and daily life being upended.

This role gave Jo the experience using GIS that's so valuable for volunteering with MapAction – but has volunteering benefited her work at the Met Office?

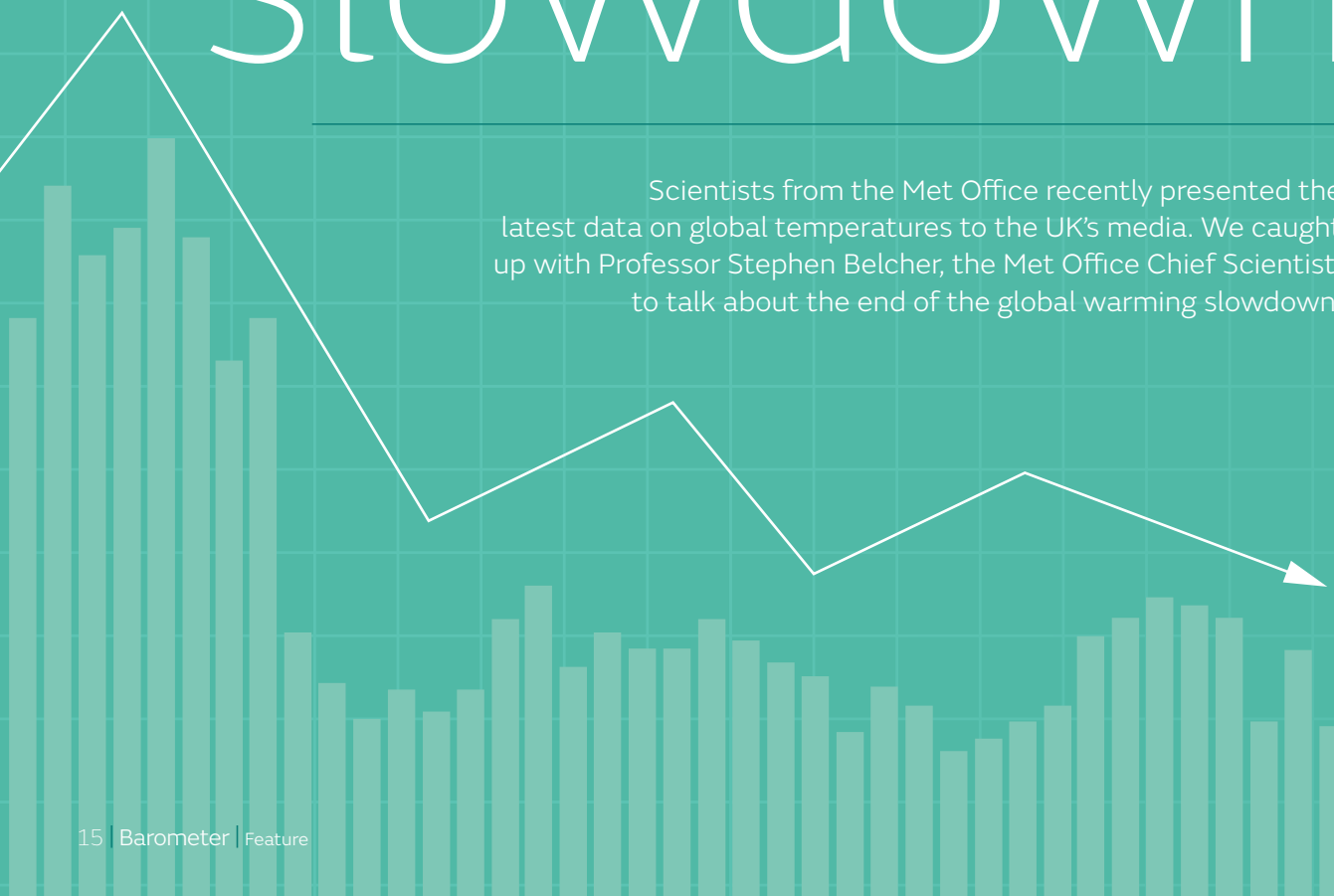
"Yes, I really think so," says Jo. "It's given me an understanding of what the big questions are when it comes to responding to an emergency, and how different organisations have to work together – and that really helps me in my day job. Now, when I'm building a forecast hazard map or risk tool I can use my experience with MapAction to think 'what would actually be the most useful thing to know both before an event and during the response', which can help direct the sort of research I think will be useful."

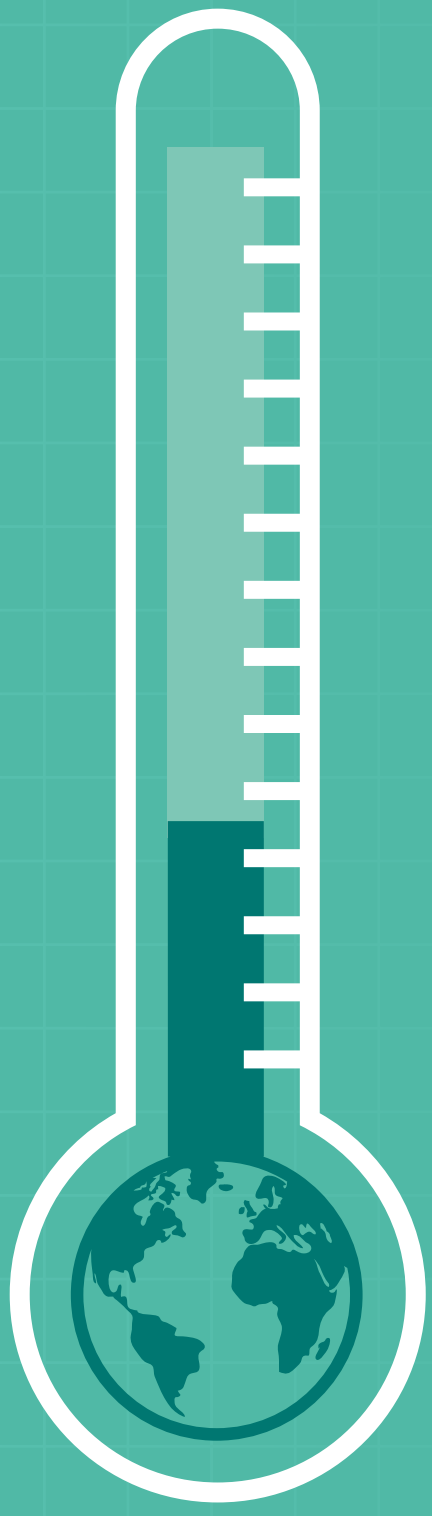
With the Met Office's support, Jo aims to be available for deployment with MapAction once a year. "I've always wanted the work I do to be useful and help people," she says. "The feeling that what I'm doing contributes to something bigger is really rewarding."

To find out more about MapAction, support the charity, or apply to become a volunteer, go to www.mapaction.org.

The low-down on the slowdown

Scientists from the Met Office recently presented the latest data on global temperatures to the UK's media. We caught up with Professor Stephen Belcher, the Met Office Chief Scientist, to talk about the end of the global warming slowdown.





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Q. Much media attention was given to the idea that global temperatures stopped rising, the so-called 'slowdown'. What does the latest data show us?

A. From 1999 to 2014 Met Office figures showed that the rise in the average global temperature had slowed compared to trends in the 1990s. However, latest data from the Met Office show that this slowdown has come to an end.

Q. So have we seen a large change in recent temperatures?

A. Global temperature values in 2015 and 2016 both broke records and were about 1 °C higher than pre-industrial levels, which is taken to be the period between 1850 to 1900. So the data shows that the long-term rate of global warming has now returned to the same level reported during the second half of the 20th century.

Q. And does it look like 2017 is going to be a record-breaking year too?

A. We don't think it will be. So far 2017 has already exceeded the 1 °C threshold, but the temperatures this year aren't influenced by El Niño conditions, which tends to increase the global mean temperature. So this leads us to think that it won't be a record-breaker.

Q. What do you think is behind the rise?

A. Greenhouse gases and aerosols explain much of the long-term increase in global mean temperature, but natural variations in climate also have an influence on the warming over shorter periods. For example, an event such as El Niño tends to lead to a higher global mean temperature. That can go the other way too. Variations in climate in the Pacific led to the slowdown that we saw from 1999 to 2014.

Q. In what way did the Pacific influence these recent figures?

A. The surface temperatures of the Pacific Ocean can oscillate between warm and cool phases. It's called the Pacific Decadal Oscillation, and until fairly recently the oscillation was in a negative phase. That meant the ocean was subducting heat into the deep ocean, and reducing the warming at the surface, which is what is measured by the global mean temperature. Now the Pacific Decadal Oscillation has entered its positive phase, and we're seeing warming of the tropics, the west coast of North America and the globe as a whole.

Q. Is this warm phase here to stay?

A. No one can answer this question! We would need to understand the Pacific Decadal Oscillation in much more detail before we could make any predictions about how long we will stay in this warm phase.

Q. Don't we see slowdowns of the temperature rise fairly often?

A. We saw a slowdown in the early 20th century, and a slowdown between the 1950s and the 1980s. For the first slowdown, temperature records show there was a lot of 'noise', which is what might be expected by natural variability. In other words, this is what happens in a climate with little human influence. For the second slowdown, there is a strong effect from aerosols, which are small particles in the atmosphere natural sources and human activities. The high levels from human activities during the second slowdown led to what is known as 'global dimming'. Clean air legislation reduced emissions of these aerosols, and we've since seen global brightening. In the absence of aerosols masking global warming, the warming of our climate by greenhouse gases is now more apparent.

Q. So should we expect more slowdowns in the future?

A. Well, natural influences like the Pacific Decadal Oscillation and El Niño will continue to affect global temperatures and it is difficult to predict exactly when these will happen. But, overall, an increase in greenhouse gases in the future will mean that global temperatures will continue to rise, even if this rise isn't perfectly smooth.

Eye on the storms

The year 2017 is bound to go down in the history books for the severity of the hurricane season. Hurricane Irma in particular caused devastation across the Caribbean, wrecking infrastructure and causing fatalities on islands like Barbuda. The year saw a heavy Southern Asia monsoon too. So can we say these events are a direct cause of climate change?

Professor Belcher is quick to urge caution. "The only way to properly determine that would be by comparing weather events with what would have been the case without climate change," he points out. "However, we do already know that a warmer atmosphere can hold more moisture, which can lead to increased rainfall."

Another factor that may have an influence is rising sea levels caused by climate change. Any hurricane storm could have more impact because of rising seas, creating an additional peak to any surge.

Wheat rust in Ethiopia

Wheat rusts can devastate crop yields in Ethiopia, yet a new, wide-ranging partnership could lead to more effective crop protection across the country.

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Wheat rusts are fungal diseases that can cause devastating losses to yields of the crop. In a country like Ethiopia, where wheat is a key part of the diet and of the economy, a poorly performing crop can have a huge impact. Yet fungicides are only half the answer. Spray a field at the wrong time or in the wrong area, and not only will the crop still be at risk, the cost of the spray will have been wasted.

Spores of wheat rusts are spread by the wind, potentially over hundreds of kilometres. Other factors influencing this spread include rainfall and ultra-violet light affecting the deposition and lifetime of the spores as well the environmental conditions at the wheat rust locations and at the locations of crops down-wind.

Now, to help minimise the impact of wheat rusts in Ethiopia, the Met Office has joined forces with the University of Cambridge, the Ethiopian Institute of Agricultural Research (EIAR) and CIMMYT, the International Maize and Wheat Improvement Center. This is being made possible through funding from The Gates' Foundation, Department for International Development (DFID) and the Biotechnology and Biological Sciences Research Council (BBSRC).

The partnership uses an atmospheric dispersion model to simulate the spread of the wheat rust spores to produce regular forecast maps to help farmers on the ground keep track of the most likely areas at risk from wheat rust. The current project aims to develop this further to provide a robust, routine feed of wheat rust forecasts to the authorities in Ethiopia. By knowing which way the spores are heading, farmers can take timely and appropriate action to save their crops.

> *"So much of what we do in our group is about collaboration, because NAME can be used in so many different ways. While we are the experts in meteorology and dispersion modelling, we're not the experts in plant-biology, radiological dosage or volcanic ash damage to aviation for instance, so we're constantly reaching out to other organisations to harness their expertise."*
>
> **Sarah Millington, Scientific Manager**

Wheat rust dispersal map showing the potential spread of spores from known rust locations (dots) for a 24-hour period in November 2017.

The project began at the University of Cambridge, where graduate student Marcel Meyer is studying for a PhD, co-supervised by the Met Office, in the epidemiology of wheat rusts. Marcel used the Met Office's Numerical Atmospheric dispersion Modelling Environment (NAME) to model the dispersion of rust spores by the wind and generate forecasts for the outbreaks.

Those forecasts led to a prototype system of reporting, whereby dispersion maps are sent to CIMMYT who compile a report to send out to Ethiopian farmers via government authorities. Anecdotal evidence suggests the report is already extremely popular on the ground. The Met Office is now helping to develop the prototype and include other factors in the modelling, such as ultra-violet light decay of spores; meteorological dependence on the release of, and infection by, spores, thereby creating more detailed risk maps for farmers.

Sarah Millington is the manager of the Radiological and Biological team in the Atmospheric Dispersion and Air Quality group at the Met Office. Will Thurston, a scientist in her team, is leading the Met Office effort on the science and technology for the project. They are both excited by the opportunities that the work opens up.

"It's all about impact on the ground," says Sarah. We're thinking about what we can produce that will help government agencies in Ethiopia make decisions and advise farmers directly."

Experts in their fields

Up until now, wheat rust observations have been collected by government agencies and CIMMYT in Ethiopia. However, an interactive phone service enables farmers to dial in with reports of wheat rust outbreaks.

"Asking farmers to report on outbreaks is an extremely pragmatic solution," explains Sarah. "Go out to Ethiopia and you'll see farmers ploughing fields with oxen, but many have got mobile phones in their pockets."

> *"Stem and yellow rust represent the greatest disease threat to Ethiopian wheat farmers; with both diseases capable of causing huge losses. Early warning is critical if good control is to be achieved. The NAME dispersal model has opened up new disease forecasting opportunities, which can result in awareness and control in farmers' fields ahead of the advancing disease."*
>
> **Dave Hodson, Senior Scientist**
> **International Maize and Wheat Improvement Center (CIMMYT-Ethiopia)**

The data of wheat rust locations will be fed into NAME to produce large-scale dispersion outputs covering hundreds of kilometres. By then feeding these outputs into an epidemiology model at the University of Cambridge, the team will create maps of long and short-range potential wheat rust spread. They could be instrumental in helping farmers understand when and where they need to spray crops, ensuring better yields and less wastage of fungicide.

Once the two-year project is complete, Sarah and the project team hope that the work will continue. "We'll be running training and workshops in Ethiopia," she explains, "and a couple of scientists will come to the UK each year to better understand the science behind it."

Although NAME has been used for modelling agricultural diseases and viruses before, what makes this project so unique is the wide variety of partners who are involved, from the Ethiopian farmers and Government to the Plant Sciences department at the University of Cambridge. All bring different expertise and practical knowledge to the table.

"No one group could do this by themselves," adds Sarah. The pool of knowledge that it creates could make a large difference to farmers in Ethiopia. "It's a really exciting project to work on and it's good to know that the work has already had an impact," says Sarah.

Extreme measures

How can you accurately calculate the chance of extreme weather, when there's little precedence on which to base predictions? Here's where an innovative research technique using the Met Office's supercomputer is breaking new ground.

The UK has been hit with a series of extreme rainfall events in recent years. The winter of 2013/14 brought storms with record rainfall and flooding in many regions. In December 2015, Storm Desmond caused widespread flooding and storm damage in the North West, prompting the government to launch the National Flood Resilience Review.

As part of this review, the government asked the Met Office to assess the likelihood of a worst-case scenario for extreme rainfall over the next 10 years. However, predicting extreme weather is not straightforward. It is, by its very nature, a rare occurrence, which means there are very few observations on which to base research. Not only that, historical observations from before 1980 may no longer be relevant, since the climate has changed considerably. To overcome the lack of real data, the Met Office did something entirely new.

A game changer

Using the supercomputer, Met Office scientists were able to simulate thousands of possible weather scenarios and therefore create a considerable body of virtual observations. These simulations were based around the Met Office decadal prediction system where large ensembles are initialised with observations and allowed to evolve freely. In the end, one hundred times more possible simulations of the current climate than is available from real observations.

The researchers have named this new research method Unprecedented Simulated Extremes using ENsembles, or UNSEEN, to emphasise that the analysis anticipates possible events that are yet to be seen.

This is the first time that model simulations have been used in this way – and the results were striking. Analysing these simulated events showed there is a 7% risk of record monthly rainfall in south-east England in any given winter. When other regions of England and Wales are also considered, this increases to a 34% chance. In other words, even with the current climate, it is likely there will be one or more monthly regional record extreme rainfall events in the coming decade.

It can also be used to highlight month where certain regions have so far by chance been 'lucky' not to have experienced a more extreme rainfall event so far. For example, in the South East, the model simulations show a record rainfall is most likely to take place in December. Moreover, as Vikki Thompson, Climate Dynamics Scientist at the Met Office, explains, "Some of the climate dynamics we've seen in the research are dynamics we haven't seen in the real world. Yet when we assessed them, we found they are plausible."

In one simulated event, for example, the atmospheric conditions across the North Atlantic were different to what would normally be expected for a winter of heavy rainfall in the UK. On further examination, it transpired that the rainfall was being caused by moist air coming from the tropics. This would cause a warm but much wetter winter.

A better handle on risk

The applications of this ground-breaking research are significant. Now, the Met Office is able to specify how much rainfall a flood mitigation strategy would need to prepare for. "Whilst statistical methods exist using observations alone to estimate the risk of record rainfall," says Vikki, "our new technique allows us to give a more precise estimate for a one-in-100, or one-in-20 scenario." For contingency planners and engineers building a bridge or flood defences, for example, this new information is crucial. However, the applications go far beyond extreme rainfall. Since this new methodology is based on a global model, it has multiple applications around the world.

Taking the research further

The Met Office is already applying this new methodology to assess the likelihood of other extreme weather events. Met Office researchers are currently assessing the likelihood of a winter even colder than that of 2010 in the UK. Another significant project is investigating the likelihood of the maize crop in China and the United States failing simultaneously as a result of extreme heat and dry conditions – an event that would have a catastrophic impact on the global food market.

It is a global model and methodology with almost endless possibilities – and it could be an essential tool in helping countries around the world implement effective contingency strategies for the future.

See page 20 for a profile on Vikki Thompson, Climate Dynamics Scientist.

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 Vikki Thompson

Climate Dynamics Scientist

Climate dynamics is the study of how different components that make up the climate system interact with each other. It's a key part of Vikki Thompson's role to have a deep understanding of how a small change in one part of the system – such as the atmosphere or the ocean – can have large implications on the climate as a whole.

Interaction has very much characterised Vikki's career as a climate scientist – starting with her cross-disciplinary academic background. It was while studying Physics at the University of Durham that she became interested in climate science. She graduated with a BSc in Physics and Earth Science and, from there, completed a master's in Oceanography, which incorporated elements of climate science. "This has been very useful," she explains, "as the basic physics behind the ocean and the atmosphere is similar."

After attaining a doctorate in Meteorology, Vikki joined the Met Office in 2015. For Vikki, working for a world-renowned centre had big appeal. What surprised her was the sheer breadth of what the Met Office does. "It's amazing the range of work that's carried out here," she says. "I knew about the climate science, but there's all sorts of other forecasting going on – like space forecasting, for example."

Sharpening predictions

Vikki is a member of the Met Office Monthly to Decadal Prediction Group. Currently these decadal predictions currently range up to five years ahead, and as Vikki explains, "This is now developing really quickly, particularly thanks to the new supercomputer and increase in ensemble size."

Vikki is also part of the team involved in studying the likelihood of extreme weather events. The novel approach of using the supercomputer to generate virtual simulations has already enabled the Met Office to generate more accurate risk calculations for extreme rainfall in the UK (see Science Focus on page 19). Now, this method is being shared with strategic partners around the world.

"It's amazing the range of work that's carried out here, I knew about the climate science, but there's all sorts of other forecasting going on – like space forecasting, for example."

Forging partnerships

As part of the Climate Science for Service Partnership China project (CSSP China), Vikki is involved in applying this new methodology to studying the likelihood of summer heatwaves in the Yangtze region of China. Vikki is quick to emphasise that the focus of the partnership is on providing climate services – in other words, turning the science into a service that's useful on the ground. As Vikki explains, "One of the aims of CSSP China is to form partnerships with scientists in China." Vikki has visited China to meet and engage with her counterparts there – and the resulting knowledge exchange is hugely useful. "It's interesting to see what our Chinese counterparts are doing and to forge links with scientists we wouldn't otherwise meet."

These strategic partnerships are tremendously valuable, and Vikki has just started working on CSSP Brazil. "We'll be using the same new research paradigm to study the likelihood of droughts in the Amazon." For Vikki, applying this research paradigm in different ways is a fascinating area of study. "I like playing with the models; we have so much data and could do so many things with it. The possibilities are exciting." Knowing that this research could have real and lasting benefits for the world is part of what makes it so fulfilling. As Vikki says, "This work matters to everyone."

The Royal Charter gale

On the night of 25 October of 1859, a severe, slow moving storm struck the British Isles. In the aftermath, the sinking of the Royal Charter inspired Robert Fitzroy to start a national storm warning system – the earliest beginnings of today's Met Office forecasting service.

The Royal Charter gale, as it became known, was the most severe storm to hit the Irish sea in the 19th century. Wind speeds in the Mersey were higher than any previously recorded.

The storm took 800 lives and 133 ships, with 90 more badly damaged. Twice as many people were lost at sea around the British Isles than in the whole of 1858. The most famous ship to be lost during the night was the steam clipper, Royal Charter, which foundered on the coast of Anglesey. She was one of the fastest emigrant ships operating during the Australian gold rush and was on the last leg of her two-month journey from Melbourne to Liverpool.

As conditions in the Irish sea deteriorated, the Royal Charter was driven inshore. Her anchor chains snapped, and her engines were unable to make headway against the gale. She struck the rocks at Point Alerth and, battered by huge waves, quickly broke up. Around 460 lives were lost including all of the women and children aboard. There were only 40 survivors and it remains the highest death toll of any shipwreck on the welsh coast.

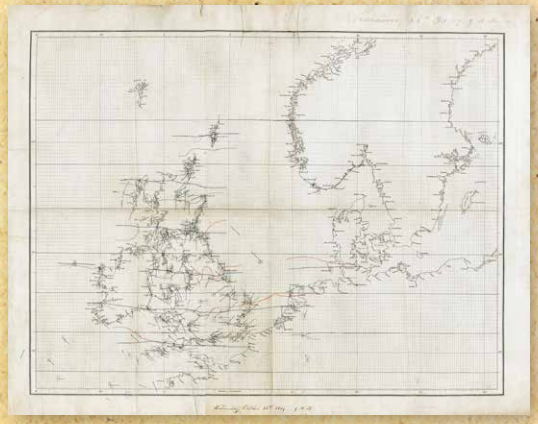
World's first national forecast warning service

Widespread coverage in the national press focused attention on the need for storm warnings to reduce similar losses in future. Robert Fitzroy, founder of the fledgling meteorological office, which had been collecting observations from around the British coast since 1854, believed his department could provide such a service. He produced a detailed report with charts to prove that the storm could have been predicted. Through his analyses of the Royal Charter and other storms, Fitzroy demonstrated the validity of his models and proposed a national storm warning system.

Many in the scientific establishment doubted that weather could be predicted in any meaningful way. However, the government permitted Fitzroy to test his science of weather forecasting and establish a storm warning service. In February 1861, the first warning was issued using a combination of cones and drums hoisted on a mast to warn vessels both in harbour and along the coast of an approaching gale. On the Tyne, the warning was disregarded and many lives were lost, however its accuracy ensured that further warnings were heeded and the scheme was widely popular.

Long lasting legacy

Fitzroy became a hero to the maritime community and the RNLI. Although there was no involvement of the Royal National Lifeboat Institution (RNLI) in the Royal Charter storm as the RNLI did not have a boat in Anglesey until 1868, the forecasts helped protect many lives including RNLI lifeboat crews. Today, we work in partnership with the RNLI when handling a range of weather related events. RNLI is also our corporate charity. There are memorials to the Royal Charter on the headland at Point Alerth, Anglesey and at the RNLI Gwylfan Moelfre Sea Watch Centre. Moelfre lifeboat station was founded in 1868 and the dangerous nature of the Anglesey coastline has resulted in its lifeboat crews being awarded 37 medals for gallantry. The storm warning service is the longest running national forecasting service in the world – now known as the iconic shipping forecast – provided by the Met Office on behalf of the maritime and coastguard agency.

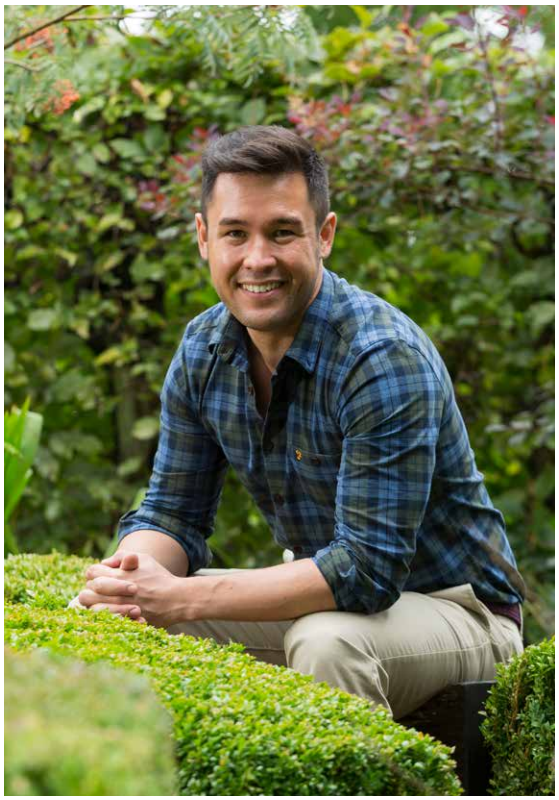


The uninterrupted service is 150 years old this year. On reaching such a milestone, it is worth remembering the Royal Charter gale, and its significance in terms of forecasting, and the origins of the Met Office as a source of lifesaving warnings.

See page 5 for an article about the anniversary of the Great Storm of 1987.

Living for plants

Presenting the TV series, Grow Your Own Drugs, or co-hosting Radio 4 shows. Designing award-winning gardens, or helping everyone eat better, tastier food through his best-selling books. As a self-confessed botany geek, **James Wong** has built a career around plants.



In fact, James can't remember a time when he wasn't completely fascinated by them. Having grown up in Singapore, he moved to the UK in 1999 to begin a Master of Science degree in Ethnobotany at the University of Kent and Kew Gardens. Ethnobotany was of particular interest to him, for the way it combines botany and anthropology to examine how different cultures around the world grow and use plants.

Shortly after graduating and completing a placement at the BBC, James joined Kew Gardens to pursue his key research interests: underutilised crop species and food systems in rural Ecuador, Java and Southern China.

Protecting the planet

The weather and climate change are naturally of crucial importance to James and his work – and he is involved with a global network that catalogues and preserves plants at critical risk of becoming extinct.

"Plants are one of many tools helping to mitigate biodiversity loss, acting rather like living solar panels to mop up carbon dioxide from the atmosphere. Amazingly, global forests remove more CO_2 every day than what's produced by all the world's transport combined. So, preserving them is essential, especially in places such as Borneo, where over 75% of deforestation has occurred in just the last 50 years," says James.

Growing knowledge

Being an avid science communicator, James is also keen to challenge certain cultural – and sometimes controversial – beliefs. For example, that 'organic' food is automatically healthier or more nutritious than non-organic. Or that locally grown food is always better for the environment.

"These might be very comforting, cosy narratives," he says, "but it's been shown that food flown in from the other side of the world produces a negligible amount of carbon emissions compared to heating the massive greenhouses we use in the UK."

Sweet taste of stress

More recently, James has been involved with some ground-breaking research into the defensive chemicals tomato plant cells produce when put under stress. These chemicals can be used in production methods known as 'dry farming', which is becoming increasingly popular in drought-prone countries such as Southern California, Spain and Israel. It works by combining sea and fresh water and reduces the plant's overall consumption of H_2O, ultimately resulting in sweeter-tasting tomatoes.

"Plants are one of many tools helping to mitigate biodiversity loss."

Breeding resistance

James is also involved with developing seeds specifically to withstand climate change unpredictability. As he explains, this is not without challenges.

"Breeding a plant that's adapted for all conditions is tricky. Instead, we're creating a comprehensive suite of new seed varieties – some of which grow well in desert-like environments, and others that can cope with waterlogging. It's a long, painstaking process. Annual crops produce seeds within 12 months. But trees, like apples, need 20 years' worth of generations to reveal enough meaningful characteristics."

Magic mushrooms

Another area of interest for James is how fruit and vegetables are stored before getting to market, known as post-harvest technology. The methods employed can make a huge difference to the nutritional value of the food. A great example of this is how placing fresh mushrooms on a sunny windowsill for a few hours increases their Vitamin D content by an incredible 1,000%. This is because the ergosterol in mushroom membranes reacts like our skin when exposed to UV light. As James concludes:

"Every food you eat, and every breath you take, is quite literally created by plants. So they're pretty fundamental to humanity. And what I love about science is that accuracy is what matters, not popularity. If I find a surprising fact buried deep within a scientific journal and turn it into something people get excited about and can actually use – things like that really make my day."

#280characters

In November, Twitter increased the number of characters in a tweet from 140 to 280.

To celebrate #280characters, we came up with an emoji weather forecast map. It proved very popular, being retweeted by Springwatch among over 300 others and generated some great comments.

Keep in touch with all our latest news and advice on Twitter, Facebook, Instagram, Snapchat and YouTube.