Met Office

BROAD OUTLOOK
Keeping global perspective

WORLDWIDE WEATHER
Predicting and protecting

TEAM EFFORT
International collaborative research

Barometer

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More people than ever before are turning to the Met Office for our global perspective, says Arwel Griffiths, Director of Business Development.

World vision

Increasing natural hazards around the world are raising awareness of society's vulnerability to environmental change. Global interdependency and our changing climate don't just have consequences for people living in far flung corners of the planet, but also our own UK economy and lifestyle.

Naturally, at the Met Office, we have a true global perspective, not least because the weather is a global system and responding to the challenges and opportunities of a changing climate requires international competence.

This *Barometer* provides an overview of the Met Office's international activities. Due to the breadth of our work — from the Met Office College to our defence services — we can't possibly include everything here, so this is just a sample of our work around the world.

Forecasting global weather relies on a full range of observations. The importance of incorporating observations is growing at a great rate and we are taking an increasingly collaborative and technological approach of gathering observations. For example, E-AMDAR (EUMETNET Aircraft Meteorological Data Relay) covers the gathering of observations from commercial airline flights (page 17).

It is no longer sufficient to simply consider the national situation. A climate services project funded by the European Commission known as EUPORIAS (page 19), and the Copernicus marine service, an environmental monitoring programme (page 21), are both really good examples of public services crossing national boundaries.

Collaborating with others on a European basis supports all aspects of society, including Government and commerce.

Good examples of our work include innovative solutions for the renewables industry in Europe (page 15) and the Early Warning System project we are helping to implement in Rwanda (page 11).

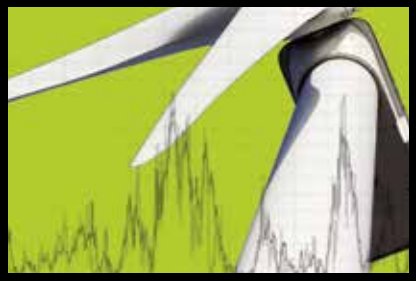
We have a strong collaboration with the Meteorological Service Singapore (MSS) and are pulling through more science to services in challenging and high-profile scientific areas. We are also establishing a regional office which means we are able to gain a detailed, regional perspective (page 13).

In Australia, a firm scientific partnership with the Bureau of Meteorology (BOM) is now broadening to include developing new applications and services. Scientific collaboration never stands still, as illustrated by the Met Office Unified Model partnership activities with like-minded organisations such as BOM and the Korea Meteorological Administration.

As unusual weather hits the headlines (page 5), an interview with the BBC World Affairs Editor, John Simpson CBE, exemplifies how our world is often shaped by the weather (page 22). In the midst of all this, the Met Office's strategy and vision is underpinned by global science.

***Barometer* is also available online at www.metoffice.gov.uk/barometer**

In this issue



News and updates

Features

People

Science

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Off on holiday?

New content on our website means that you can now find out what the weather is like in lots of top holiday destinations.

If you're off on holiday, you'll definitely want to know what the weather is up to. Our new holiday weather web pages offer our online audience monthly average climatological data and an informative overview for a variety of popular holiday locations around the world.

There are also links to the current weather situation so you can get a clearer picture of what the weather is like in your chosen destination.

With exciting and insightful content on lots of different destinations, our holiday weather pages give inspiration and advice offering ideas of what you might like to see and do while you're on holiday.

www.metoffice.gov.uk/holiday-weather

Chief Scientist in top 100

Met Office Chief Scientist, Professor Julia Slingo, has been named in the Science Council's list of the UK's top 100 practising scientists.

The Science Council organised the competition around ten different types of scientist roles, identifying people that illustrate a commitment to the practice of science with integrity, and exercise professional skill and judgement in their work. Professor Slingo was named in the Operational Scientist category.

David Willetts, Minister for Universities and Science said: "If we want more people to enter a career in science we need to show that the scientific community is not some exclusive club but people with a wide variety of vocations and interests who have rewarding careers and are making a significant contribution to the wealth and well-being of the UK."

Professor Slingo, and Met Office Chief Executive, John Hirst, were also recognised in the 2014 New Year Honours list, furthering endorsement of the Met Office's impact in the UK and abroad.

Awarded an OBE in 2008, Professor Slingo was made a Dame for her contribution to weather and climate science over a career spanning more than 30 years. John Hirst, Chief Executive of the Met Office since 2007, was awarded a CBE for his contribution to national and international weather services to benefit the public.

Television direction

The Dominica Meteorological Service is already seeing the benefits of its new television studio installed by the Met Office.

Television weather broadcasts started in Dominica early in January, introducing a new user friendly and accessible method of communicating weather information to the public.

The Met Office's Design & Innovation Specialist, David Robinson, travelled to Dominica in November to install the TV weather presentation system. He also used his extensive knowledge and experience to deliver training in design, production, presenting, communication skills and studio maintenance.

The project, implemented in partnership with the World Meteorological Organization's (WMO) Voluntary Cooperation Programme (VCP), provides another channel for the Dominica Meteorological Service to communicate information to the general public and decision-makers to help save lives and property. Daily television weather forecasts warn people of potential weather hazards like heavy rains, flash flooding, landslides, high winds and seas.

Fitzroy Pascal, Senior Level Meteorological Technician at the Dominica Meteorological Service said, "This is a step in the right direction in the development of Dominica's early warning system capabilities. It is essential that we keep abreast with technological advancements and provide weather information, both routine and adverse, to users through various media."

Working in partnership, working internationally

Societies across the globe are experiencing the impacts of climate change and severe weather. As a world-leading authority in weather and climate science, we are forming international relationships to help people across the globe.

Although we are the UK's national weather service, our work doesn't start and end at our shores. Our global capabilities mean that we work on a global scale. With our innovative products and intelligence we are helping increase efficiency and safety for customers across a range of sectors.

The challenge of climate change requires us to think and act across boundaries of nation, sector, language and culture. To help vulnerable communities across the globe we are working with businesses and governments to reduce their vulnerability to today's weather hazards, and increase resilience to future climate change.

We are no strangers to working in partnership with other weather services and research organisations around the world. Sharing the international endeavour to advance weather and climate science, we support and contribute to the international collection and sharing of worldwide observations by sea, land and air on which modern forecasting depends.

International intelligence

Our expert advice on hazardous weather conditions and the changing climate helps commercial customers and governments make essential policies and operational decisions.

We help other national weather services strengthen their ability to deliver weather and climate services to those among their populations who need them most. For example, we have used our expertise of communicating weather and science, providing consultancy to Rwanda Meteorological Agency to help set up an early warning service for severe weather (see page 11).

Similarly, The Climate Science Research Partnership between the Department for International Development and the Met Office Hadley Centre is working, in consultation with African stakeholders, to advance understanding of current and future African climate, and bring new science into use.

Beyond weather and climate

As science advances and we break new boundaries, our work continues to make a difference. Going beyond weather and climate, we are working in partnership to help others manage the impacts of a wide range of environmental hazards. We are actively involved in several projects as part of our contribution to the World Meteorological Organization (WMO) Voluntary Co-operation Programme (VCP). We also represent the UK and Met Office science at conferences such as the Intergovernmental Panel on Climate Change (IPCC), the United Nation's Climate Change Conference (COP), and through collaborations with research institutes worldwide;

Drawing on a mix of science expertise and operational capabilities from across the Met Office ensures our international work is sustainable for the Met Office, and our solutions are sustainable for customers. We feed the knowledge and revenue we generate back into our science to keep our weather and climate models among the best in the world. This benefits all of our customers, other weather services and our research partners.

Bright future

We aim to understand and tailor our services to meet our customers' objectives. For instance, our training to the global meteorological community, whether it's in Jersey, Brunei, Brazil, The Gambia or Rwanda, helps professionals on both an operational and a strategic level to understand and plan for the effects of weather and climate.

Many world-leading scientists work at the Met Office but, to ensure we achieve the best possible outcomes, we work closely with others worldwide. For example, we're working with partners including the Bureau of Meteorology in Australia and the Korea Meteorological Administration to develop the Met Office Unified Model (see page 8).

Science is crucial to our future economic and social well-being. We are transforming world-class weather and climate science into operational services that make real differences to people's lives, in the UK and overseas. More often than not, this involves working in partnership, delivering sustainable weather and climate services to make the world safer and more resilient.

Weather, weather, everywhere

Not one corner of the globe is untouched by the weather. This winter, many people felt the impacts of severe gales and storm surges in the UK. Meanwhile, extreme weather around the world put the UK weather into context.

© PA Wire/Press Association Images

In October, a severe storm, named the 'St Jude's Day storm' by the media, travelled across southern England, eventually reaching northern Europe. Gusts of up to 80 mph are rare in southern England, making the area susceptible to severe weather impacts.

Falling trees disrupted power supplies and transport, with flights diverted from Heathrow and Gatwick airports. Tragically, four people died as a result of falling trees. Our forecasts enabled contingency planners, emergency responders and the general public prepare for and limit the impacts of the storm.

Prime Minister, David Cameron said: "I think the Met Office provided good information and updated it regularly."

November began generally unsettled and wet. There were relatively few dry days, but also few frosts. Mid-November was more settled, but colder with sunshine as high pressure systems dominated. The UK experienced the first widespread frosts and some early-season snowfalls in the north.

Series of storms

From the start of December the UK entered a prolonged period of particularly unsettled weather, with a series of storms coming in off the Atlantic. A major focus of concern was high spring tides and large waves combining to cause coastal flooding. Large waves damaged sea fronts across the UK, including the historic parade in Aberystwyth.

A major winter storm on 5 December brought strong winds and a storm surge, mainly affecting the east coast. To limit impacts, we worked closely with partners, including the Environment Agency. Despite the storm surge flooding about 1,000 properties and being higher than levels experienced in 1953, advanced warnings, coupled with much improved flood defences over the last 60 years, meant that a further million homes were protected.

A succession of low pressure systems brought heavy rain and strong winds for most areas throughout December with frequent gusts of 60 to 70 mph. December was the stormiest in records dating back to 1969 and is one of the windiest months for the UK since January 1993. December was very wet across the UK, with Scotland having the wettest month overall in records dating back to 1910.

Storms hit transport, flooded hundreds of homes, and cut power to thousands of homes. Sadly, several people died as a result of the severe weather and flooding. Mild, wet winter continued into early January. Parts of England had the wettest January since records began, with the Somerset Levels particularly badly affected by flooding. Late in January, the military was brought in to help alleviate the situation.

Early in February, severe storms destroyed the railway line at Dawlish in Devon. As more areas across southern England suffered from flooding, the first Red Weather Warning of the winter in mid-February warned of heavy rain and strong winds.

Throughout the stormy season — the wettest on record — we directly supported the authorities by providing critical weather warnings and participating in COBRA emergency planning meetings as extreme weather continued to impact the UK.

Forewarned is forearmed

Following on from last year's successful campaign we again hosted the 'Get Ready for Winter' web pages to help individuals, families and communities prepare for winter.

The pages combined messages from Government, the voluntary sector, local authorities and others. We encouraged people to prepare their properties and vehicles, take responsibility for their own safety, be aware of the latest forecasts and warnings, be prepared to alter plans and look after vulnerable people.

Why wild weather?

Storms are common in winter because of the big difference in temperature between the cold air in the Arctic and the warm air in the tropics at this time of year. This contrast creates a strong jet stream, a narrow band of fast moving winds high in the atmosphere.

This winter the UK had an exceptional run of winter storms, culminating in serious coastal damage and widespread, persistent flooding. This period of weather has been part of major deviations of the Pacific and North Atlantic jet streams driven, in part, by persistent rainfall over Indonesia and the tropical West Pacific.

The North Atlantic jet stream has also been unusually strong; this can be linked to exceptional wind patterns in the stratosphere with a very intense polar vortex.

The jet stream can guide storms as they come across the Atlantic, bringing storms to the UK. It's possible for the jet stream to increase the strength of storms, but storms can also increase the strength of the jet stream. This 'positive feedback' means storms often cluster together.

As yet, there is no definitive answer on the possible contribution of climate change to the recent storminess, rainfall amounts and the consequent flooding. This is in part due to the highly variable nature of UK weather and climate.

Nevertheless, recent studies have suggested an increase in the intensity of Atlantic storms that take a more southerly track, typical of this winter's extreme weather. There is also an increasing body of evidence that shows that extreme daily rainfall rates are becoming more intense, and that the rate of increase is consistent with what is expected from the fundamental physics of a warming world.

More research is urgently needed to deliver robust detection of changes in storminess and daily/hourly rain rates and this is an area of active research in the Met Office. The attribution of these changes to anthropogenic global warming requires climate models of sufficient resolution to capture storms and their associated rainfall. Such models are now becoming available and should be deployed as soon as possible to provide a solid evidence base for future investments in flood and coastal defences.

Worldwide weather

Weather often has significant impacts that put lives at risk. From intense heat in Australia and extreme cold over North America to Typhoon Haiyan, we monitor conditions around the world, keeping an eye out for severe weather. Our range of services and advice enable organisations like the Foreign and Commonwealth Office (FCO) and the Department for International Development (DFID) to make informed decisions. We also collaborate with and advise other weather services, for example in Africa (see page 11).

Philippines

North America

© AP/Press Association Images

Typhoon Haiyan

In November, Typhoon Haiyan, one of the most powerful storms ever recorded to hit land, made landfall over the central Philippines, causing catastrophic damage through the Philippine islands of Samar, Leyte and Panay.

As well as strong winds, the storm surge and heavy rain also caused major impacts. Thousands of people were killed and the UN estimates more than 11 million people were affected and some 673,000 displaced. The city of Tacloban was particularly badly hit.

After leaving destruction in its path, the typhoon moved out into the South China Sea, losing some strength before making another landfall in northern parts of Vietnam. Regional warnings for Typhoon Haiyan were produced by the Japanese Meteorological Agency and the Philippine Atmospheric Geophysical and Astronomical Services Administration.

We supply predictions of typhoon tracks from our global forecast model to meteorological centres worldwide, which are used with guidance from other models to produce forecasts. We are currently working closely with the Philippine Government to provide model forecasts and guidance for their region as part of ongoing collaborative work. This has proved beneficial in predictions of the recent tropical storms Lingling and Kajiki which both affected the region struck by Typhoon Haiyan.

Professor Alfredo Mahar Francisco A. Lagmay, who leads Project NOAH (Nationwide Operational Assessment of Hazards) in the Philippines, said Met Office forecasts "...aided greatly in the projections for the typhoon's impact as well as in the storm surge simulations generated by the group to determine vulnerable communities. This led to successful disaster mitigation efforts in various areas which saved numerous lives."

Extreme cold over North America

Weather over North America hit the headlines in January when record breaking cold conditions spread south from the Arctic. In the US, many people linked the extreme cold to a 'polar vortex'. Traditionally, in the UK, this term is normally used to describe the persistent large-scale low pressure situated around 50 km above the poles in the stratosphere.

However, the American use of the phrase 'polar vortex' referring to the extremely cold conditions over North America is different to the definition above, instead referring to features lower in the atmosphere — in the troposphere, where our weather happens.

Usually, in winter, a deep reservoir of cold air becomes established through the lower atmosphere over the Arctic because of the lack of sunlight. This is usually held over high latitudes by the jet stream.

This winter the jet stream weakened and moved southwards over North America in the wake of a low pressure system as it moved east out of the USA and over the Atlantic. This allowed the reservoir of Arctic cold air to move southwards across the US, resulting in extremely low temperatures.

Cold weather in the US didn't mean cold weather in the UK. We get our coldest weather when winds blow from the northeast or east from the continent. In fact, cold weather in the US can strengthen the weakened jet stream and bring the UK milder and wetter weather, much as we have seen.

Model partners

Collaboration with scientists at operational and academic centres around the world is crucial for the development of the Met Office Unified Model (MetUM) — our seamless numerical modelling system.

Before 1990, the Met Office used several different modelling systems for predicting the weather, including global, regional and fine mesh numerical weather prediction (NWP) and climate models. The move to a Unified Model consolidated different scales and meant that all the models could use the same code and run on our high-performance supercomputer.

Since those early beginnings, the Met Office Unified Model or 'MetUM' has grown to contain over a million of lines of code. Met Office UM Partnerships Manager, George Pankiewicz makes it possible for the MetUM suite of software to be accessed by partners across the world, both in national meteorological services and academia, who contribute to scientific and technical development.

Collaboration is key to the MetUM's ongoing success. "We simply don't have the resources and expertise to maintain and develop a world class model on our own, given the increasing level of scientific and technical effort that will be needed." explains George. Consequently the Met Office has teamed up with a number of international partners — including organisations in Korea and Australia, with India coming onboard soon — to input their expertise and enhance the model. ➔

New consortium, new opportunities

The partnerships and the MetUM will be overseen by a new consortium headed by core partners; the Met Office, the Centre for Australian Weather and Climate Research and the Korea Meteorological Administration. The consortium has agreed that every core partner involved must assign four people a year to the scientific and technical development of the project, as well as financial support to pay for direct support and collaboration services.

"The ultimate goal is a model that's fit for purpose in many applications, from convective scale NWP in many locations around the world, through to complex global earth system modelling," explains George. "It's about building a robust system that you can use for operations but is also a research tool open to everyone."

The consortium's next goal is to consolidate all MetUM code into one repository, which all Met Office partners can access and work from online, rather than shipping out individual code across the world. Much attention is focused on the technical infrastructure, as Korea and Australia use different computer, observation and post-processing systems from the Met Office. With one consistent framework in place, setting up and using the model will become more straightforward for partners.

Lifesaving work in Australia

By bringing in partners from across the globe, the Met Office is ensuring that MetUM can handle a huge diversity of scenarios. For instance, Australia is particularly strong in tropical meteorology and the Southern Ocean, while partners in India are experts in monsoon forecasting.

Where next for the MetUM?

George Pankiewicz, Peter May and Christian Jakob discuss their visions for MetUM's future.

George sees a future where more and more scientists will get involved, providing inspiring leadership and vision. Once the infrastructure work is complete, the partners will focus on more global model evaluation, including work on tropical, Southern Ocean and monsoon predictions. From air masses to land surface, from fresh water run-off to ocean temperature, there are multiple parameters in predicting the Asian monsoon, and it will take a lot of teamwork to rise to the challenge.

Peter believes that the 'big science' of weather prediction will lead to even greater achievements — saving more people's lives in the process. "One of the scientific triumphs of the twentieth century is the weather forecast," he says, "with millions of observations, using super computers that were simply unimaginable two decades ago."

Christian is hoping for 'MetUM sans frontières'. In other words, a future with seamless collaboration between science teams across the globe. So if someone is interested in mapping the monsoon, they can be part of it and make a vital contribution.

The partnership with Australia began around seven years ago, when the Bureau of Meteorology (BOM) and the Commonwealth Scientific and Industrial Research Organisation (CSIRO) joined forces to look at various modelling options. The decision was taken to draw a line under their own independent developments and partner with the Met Office, with MetUM now at the heart of the Australian model.

Peter May, acting Deputy Director at the Bureau, is pleased with the progress so far. "If you look at our numerical weather prediction performance, you can see a very distinct step change in the reliability of our warnings," explains Peter. For instance, when there was severe flooding in Victoria, warnings were issued five days in advance — a timeframe that would only have been dreamt of ten years before.

There are similar advances in forecasting tropical variability, such as the monsoon onset, which has always been extremely difficult. The work is literally lifesaving. For instance, work in bush fire weather highlights the importance of local terrain effects and complex physics, with the potential to save many lives.

Blue sky thinking

Partnerships with academia in Australia are also proving extremely beneficial for the MetUM. Christian Jakob, Professor in Atmospheric Science at Melbourne's Monash University, is researching and developing atmospheric physics components for use in weather and climate prediction. He is part of the Australian Research Council's Centre of Excellence for Climate System Science, a team from five universities collaborating with the Met Office and helping to build the infrastructure. Thanks to academia's focus on research, the partnership can stretch and test the model even further than the Met Office's already rigorous standards.

"The Met Office wants to improve the model, which requires a lot of testing and often involves small, incremental steps," explains Christian. "The academic world doesn't have that constraint — so we can take more risks and engage in blue sky thinking."

Another key aspect of collaborating with academia is that it is a much more diverse community, and requires even more flexibility from the modelling system. Consequently the Met Office's Australian partners have huge experience in building infrastructure. One of the most important principles of science is reproducibility, whereby an experiment can be carried out by scientists anywhere and lead to the same verifiable conclusions. "By helping to develop a joint infrastructure we can be sure we're comparing apples with apples," says Christian.

Model development is becoming an ever more difficult task. Christian draws the analogy with a medical breakthrough, where millions of hours in the laboratory eventually lead to a small advance and the next step forward. That's what makes a consortium so attractive, as with different backgrounds, experiences and ways of looking at challenges, everyone involved is increasing the chances of the next breakthrough. "The models have been developed for thirty years, and all the easy problems have been solved," says Christian. "What's left now are the hard ones."

Korea

Korean connection

The Korea Meteorological Administration (KMA) is now a key part of the Unified Model Partnership working closely together developing the model collaboratively. Since the Koreans implemented the MetUM in 2010 it has shown excellent performance in East Asia.

As Sangwon Joo, Director of the Numerical Data Application Division at KMA explains: "We are very happy with the UM. In a recent survey on MetUM performance, Korean forecasters answered that the MetUM is much better than equivalent models over East Asia."

KMA and the academic community in Korea bring a range of skills to the partnership as part of a global modelling community focussing on specific phenomena and contribute to evaluating and improving the overall performance of the MetUM.

"The MetUM is a global model, but the Met Office has focussed on its performance over the European countries, but as a partner we can focus on the performance over East Asia, specifically typhoon prediction and heavy rainfall over the east part of the Korean peninsula. In future we will develop parts of the model, especially in terms of typhoon forecasting combined with our new forecasting technique," says Sangwon.

Importantly, KMA involvement doesn't just improve typhoon prediction over Korea but in different areas, including the Southern Oceans.

KMA not only runs a global version of the model but high-resolution versions as well. For several years, we have been able to improve the performance of the model through external evaluation but now other organisations in other parts of the world are now looking at the high-resolution models. At this year's user workshop a focus will be on joint development and how we can improve those models together through this partnership. KMA also works with the Australian Bureau of Meteorology (BOM) collaborating on how to incorporate observations into the model and developing software to use model output in different formats.

"We are trying to introduce more observations, for example from radar radiosonde, or wind profiler, into our high-resolution model system to improve its performance," explains Sangwon.

KMA scientist, Yoonjae Kim is currently working at the Met Office on the software for the observation assimilation system, working out how best to combine these with the high-resolution model to implement improvements at the Met Office that have already been made in Korea.

Similarly, Met Office Data Assimilation Scientist, Adam Clayton, is working at KMA. The KMA shares its computer resources and infrastructure making it possible to run large experiments. One element of the partnership is running a joint seasonal production system. Sharing resources in this computationally intensive area is of real benefit.

By engaging with staff, Adam understands how things work and how working practices and cultural differences vary between the two countries; all the while this serves to improve communication between the partners. The technical nature of the work, language barriers and time differences all make working in partnership difficult so these relationships are absolutely crucial to a successful partnership.

Sangwon spent two years working at the Met Office evaluating the impact of satellite data on the MetUM using the Forecast Sensitivity to Observations system, a way of working out the value of each observation, which has been implemented at KMA. "We can evaluate each individual observation to determine how it improves or degrades the forecasting system. We can then focus on certain quality control or other processes of each observation and reorganise the observation network", says Sangwon.

Rwanda

Saving lives by reading the rain

A pilot rainfall Early Warning System (EWS) for disaster management — designed with Met Office input — looks set to make life safer in the mountainous north-west of Rwanda.

As is typical in the tropics, when it rains in Rwanda it really does pour. When torrential rainfall comes to the heavily populated Gishwati area, its effects can be devastating. Severe deforestation over recent decades has led to degraded mountain soil and erosion that not only cause fatal flash flooding, but treacherous landslides too.

Rising to the challenge through partnership

Designed to tackle one of Rwanda's most pressing public safety problems, the pilot rainfall EWS is a Met Office collaboration supporting multiple partners. These include Metéo Rwanda, the national meteorological office, as well as the Ministry of Disaster Management and Refugee Affairs (MIDIMAR) and the Rwanda Environmental Management Authority (REMA).

Seasonal forecast training, which included a Regional Climate Outlook Forum — a first for Rwanda — is the second key strand of Met Office support.

Both initiatives follow preliminary work by the Met Office's Helen Ticehurst, who spent 2011 in Rwanda, focussing on capacity building.

"During her year, Helen started scoping out what an EWS might eventually look like," explains Bill Leathes, Met Office International Development Manager. "Having someone on the ground at that early stage was extremely useful."

The starting point: listening to users

Bill's Met Office team worked with Metéo Rwanda's Chief Forecaster Anthony Twahirwa and REMA's project manager Alphonse Mutabazi to first identify what rainfall information was needed. This 'bottom up' approach involved bringing service providers and users together through workshops and visits to disaster managers in the field. Previously, weather services were set up with little user engagement.

"For example, did users need to know what's going to happen in two hours, two days or throughout the rainy season?" says Bill. "By asking the right questions, we were able to come up with two main types of product: a five-day rainfall planner and a warning service for when conditions are looking particularly dangerous."

> "Designed to tackle one of Rwanda's most pressing public safety problems, the pilot rainfall Early Warning System sees the Met Office supporting multiple partners."

The five-day rainfall planner is now live and emailed out every six hours from Metéo Rwanda to all central ministries who are represented on the National Disaster Management Committee (DMC), as well as local DMC members. The warning service highlights specific events that could bring danger to lives and property.

Both services are designed to use existing communications systems, although there remains work to be done to maximise MIDIMAR's text-based infrastructure and network.

Making the most of EWS potential

Once the pilot EWS products were designed, there was still plenty to do. While Alphonse Mutabazi at REMA managed EWS matters outside the Met Office contract — including the procurement of 22 new automatic weather stations — the Met Office focused on developing standard operating procedures as part of the introduction of a quality management system.

"We've delivered a great deal of mentoring and training," adds Bill Leathes, "both for experienced forecasters as well as newly qualified people — a number of which had already trained with us through a previous project."

Looking ahead to 'Stage 2'

Although proof of the pilot's effectiveness will only come in the February to May rainy season, the Met Office and our Rwanda partners already have an eye to the future. Aspects of the EWS could be decentralised to district level. And new warning systems could focus on other weather threats such as lightning, fog or floods — as well as other geographical areas.

As EWS roles and responsibilities continue to be defined and refined, Rwanda's people face the future in a country that's thankfully not only now relatively peaceful and stable — but one where extreme weather threats are also being addressed.

Committed to Africa

Other Met Office projects in Africa have included:

New infrastructure and services for Sierra Leone
A United Nations Development Programme (UNDP) contract saw the Met Office help to rebuild Sierra Leone's war-shattered weather capabilities involving site selection, automatic weather system (AWS) design and procurement, and technical training.

Climate Science Research Partnership
The CSRP involves the Department for International Development (DFID) and Met Office Hadley Centre joining forces with various African organisations to improve understanding and prediction of the African climate to help alleviate poverty.

Supporting the global Regional Climate Outlook Forums initiative
Regional Climate Outlook Forums covering the Greater Horn of Africa (GHACOF), Southern Africa (SARCOF), West Africa (PRESAO) and Central Africa (PRESAC) see the Met Office bringing together diverse experts to improve climate outlook capability — and make best use of the outputs.

Support for the WMO's Severe Weather Forecasting Demonstration Project (SWFDP) in East Africa
The Met Office Global Guidance Unit is helping regional meteorological centres in Nairobi and Dar Es Salaam make the most of Numerical Weather Prediction (NWP) to improve severe weather forecasting in Burundi, Ethiopia, Kenya, Rwanda, Tanzania and Uganda.

The Ada Consortium in Kenya
Funded by DFID, the Ada consortium includes the Met Office, Kenya Meteorological Service and NGO (Non-Governmental Organisation) partners — working to improve the production and delivery of weather and climate information services, particularly seasonal climate information and its communication in Kenya's arid north-eastern counties.

Other Met Office capacity building projects have included installing TV weather studios and other facilities across Africa.

Outside of Africa, the Met Office installed a TV weather studio for the Dominica Meteorological Service (see page 3).

Singapore

Going global

Until recently Rob Harrison and Tom Butcher were both based at the Met Office in the UK. But in the last few months they've travelled half way across the globe to take up new roles in Singapore and Australia.

By its very nature, weather and climate science benefits from people all over the world working together — which is why the Met Office has a well-developed programme of international partnerships. Decades of development work have given the Met Office a high profile reputation as an organisation that welcomes and supports external collaborators.

Singapore

Rob Harrison

Building on existing relationships
Just a few months into his new role leading Met Office activities and partnerships in South East Asia, Rob Harrison can already see a wide range of intent. "We've got some excellent partnerships in this part of the world, and a great track record of seconded scientists working with national meteorological services," Rob says. "It's also one of the few regions that is seeing significant economic growth — so there's great potential to add value to work being done by both governments and businesses."

The weather's impact in South East Asia can be particularly extreme, as the devastation caused by tropical cyclone Haiyan recently showed. In regions such as this, in-depth understanding of some of the most challenging aspects of forecasting can be crucial, and that's where the Met Office comes in.

In 2011, the Met Office signed a Memorandum of Understanding with

Australia

the Singapore National Environment Agency. The collaboration covers the joint development and implementation of weather and climate models with the Meteorological Service Singapore, the exchange of scientists and the undertaking of regional climate science research.

Opportunities for growth

Another key aspect of the Met Office's long-term strategy in South East Asia is providing services to the commercial sector, taking up opportunities to work with companies in the oil and gas, renewable energy, and defence markets. The Met Office has been successfully providing these kinds of services for over 30 years. Now it's down to Rob Harrison, and his colleague Mark McDermott, South East Asia Regional Manager for Oil & Gas, to spread the word in this part of the world. As Rob explains, the depth and breadth of the science means that the Met Office can assist with a whole range of applications:

"We can provide both average and extreme weather information for projects at the design and planning stages, but we're also seeing an increasing demand for longer-range forecasting and climate change risk assessments. Once projects are up and running, our day-to-day forecasting can support a company's operations."

While the regional office in South East Asia is still in its infancy, it is hoped that in time the partnerships with national meteorological services in the region might develop down a similar route as in Australia.

Melbourne

Tom Butcher

In Melbourne, Tom Butcher, has just taken up a secondment with one of the Met Office's most established partners — the Australian Bureau of Meteorology. He's there to help broaden their range of services and customers and also to explore mutually beneficial business opportunities, something he says is a natural progression of their long-standing science and operational connection: "We both use the Met Office Unified Model, common nowcasting systems and forecaster workstations, so it's easier for us to work together to share and improve our other capabilities."

Tom has only been in Melbourne for a few months, but as he works with his new colleagues at the Bureau of Meteorology to seek out potential new areas for growth, they'll be looking to pinpoint projects that extend the partnership both ways. This means the Bureau of Meteorology using Met Office expertise to help develop new business ideas that are suitable for the Australian market — as well as the Met Office taking advantage of the Bureau of Meteorology's strengths back in the UK and in other focus regions.

The Weather Observations Website (WOW) was originally developed by the Met Office in association with the Royal Meteorological Society to collect observations from amateur weather enthusiasts. An Australian version has just been created — a great example of the system of exchange that Tom is looking to encourage. For more information on WOW turn to the back page of this issue of Barometer. For an insight into the Met Office Unified Model, another exemplary area of collaboration, which involves Met Office scientist Stuart Webster and others in Australia, take a look at page 8.

It's hoped that these kinds of projects are just the beginning, paving the way for other regions, and as Tom says, "strengthening our partnerships so that we can all continue to benefit for many years to come."

Germany

Knowledge is power

As we move to a low-carbon future, with the decarbonisation of heating, cooling and transport, traditional energy suppliers and traders are facing a number of challenges. An innovative partnership between the Met Office and LEM-Software is providing a powerful solution.

With more and more legislation requiring the move to decarbonisation, energy companies are shifting to renewables. This development, however, brings its own set of challenges, as there is currently no suitable storage solution to preserve the energy produced by renewables. Energy is made available by the whims of the weather — which means it might not be on tap when demand is high.

An increasing use of renewables is also making energy production more volatile. For instance, if weather conditions mean there isn't any renewable energy available, then the power companies need to make sure other options — such as coal or gas stations — are working at maximum capacity. This can take days of planning, which means energy companies need a detailed forecast of renewable peaks and troughs.

At the Met Office, Head of Renewables, Michelle Spillar is heading up a project to help energy companies rise to the challenges of moving to renewables — through an innovative predictive model created by our partners LEM-Software, a German software company.

"The model isn't just applicable for forecasting energy supply, but for demand management too," explains Michelle. Ever more sophisticated forecasting means that companies can ascertain how much energy is available to meet demand, and what that means for the network. "There are pinch points at the moment," says Michelle, "for example, within the UK, a lot of wind power comes from Scotland, and companies have to be able to manage that supply on the grid."

Blowing in the wind

The need for accurate forecasting is equally as great in the renewables sector itself. Companies need accurate forecasts to be able to predict how much they will be able to produce and supply. The LEM solution enables customers to receive accurate power predictions based on our optimised weather forecast information, drilling down to extremely precise detail.

"We can take into account the exact type of site," adds Michelle. "For wind farms, we can take into account whether the turbines are 20 or 70 metres high, which makes a very big difference. Wind at the surface is influenced by buildings, but up at 70 metres in the air, the wind flows much more smoothly."

The software also benefits the energy trading sector, which relies on powerful forecast accuracy, particularly in day-ahead markets where traders have to be able to predict supply and demand very closely.

The solution is paying dividends to energy suppliers, distributors, traders and end consumers alike. As companies run more efficiently, they can pass on savings to the end users. And in a world where the energy grid is increasingly interconnected, we all benefit. For instance, if Germany can accurately predict supply and demand, they can identify the amount of surplus to sell on to other nations.

The opportunity is inspiring for the Met Office and LEM-Software. By using artificial neural networks, LEM's software is capable of 'learning'. In other words, through running historical predictions and comparing them to what actually happened, it constantly fine tunes its performance.

At a time when energy companies have targets and objectives to meet for 2020 and 2030, powerful predictive software like LEM is coming into its own. "The need for more accurate forecasting will only keep increasing," says Spillar, "And we're keen to show that we can lead the way."

A world of difference

The need for accurate weather forecasting depends on a country's own unique mix of energy sources.

For instance, Iceland uses a lot of geothermal energy, while 70% of France's energy supply is nuclear. On the other hand, Germany has moved very far into renewables, with a lot of wind and solar power. Consequently the German need for accurate forecasting is higher than many other countries.

Forecasting also plays a key role when countries access power from neighbouring states or even further afield. To take one example, as the UK builds more connections to Ireland, we can harness more of their wind driven energy in the future, and will consequently need accurate forecasting of the weather in Ireland.

The Met Office is also working with German utility company EON and their subsidiary E.DIS, providing them with accurate predictive models. Countries across Western Europe are moving quickly with renewables, as legislation stipulates the move to decarbonisation. Today, more and more countries are looking to the Met Office for powerful forecasting.

"Ever more sophisticated forecasting means that companies can ascertain how much energy is available to meet demand."

Europe

Real-time observations are taking off

Aircraft provide an essential way to gather weather data. For several years, an international programme has ensured that meteorological offices across Europe are pooling data from flights to build an even more detailed picture of weather conditions.

To map, understand and predict the weather, it's vital that every national weather service has as much up-to-date observational data as possible. That's the thinking behind EUMETNET, a programme of 30 organisations across Europe that have joined together to pool resources and observations. By collaborating, each country benefits from having more data at its disposal, and avoids any wasted cost in duplicating work being done elsewhere.

EUMETNET members share observations from a several different sources, such as radiosondes from ships and water vapour measurements using satellites. Some of the data sharing projects are compulsory for members of the collaboration, including E-AMDAR (EUMETNET Aircraft Meteorological Data Relay), which covers the gathering of observations from commercial airline flights. E-AMDAR is part of a wider AMDAR worldwide community under the World Meteorological Organization (WMO).

It's standard practice for all commercial airlines to take a number of observations as they fly, including static air temperature, air speed and ground speed (from which it is possible to derive wind speed) and indication of turbulence. E-AMDAR enables meteorological offices to harness this data, process it and transmit it onto the World Meteorological Organization's Global Telecommunications System. The data is vital especially as, apart from radiosondes, AMDAR is currently the only source of atmospheric, in-situ observation. Obviously, when more airlines are signed up to the programme, more data can be collected and harnessed for Numerical Weather Prediction (NWP).

More and better data

The E-AMDAR team is headed up by Steve Stringer. Steve started managing the programme in early 2013, after having worked in radiosondes and, as he puts it, "all things upper air". The programme is a rich source of observational data that is vital for NWP. Steve explains, "As the processing power of the models increases, they grow hungrier and hungrier for data." E-AMDAR helps to provide that real-time information.

All the data that the aircraft provide is processed and made available for the models and other countries in EUMETNET to use incredibly quickly. Predictive models are run every three hours, with some now running every hour and ideally needing fresh data within 15 minutes of the observation being made. Currently about fifty per cent of data from aircraft is available within this time window.

Steve would like to make sure that even more data is available as quickly as possible. One challenge is that aircraft take observations every seven to eight minutes, but send them in batches. In effect this means that the first piece of data in the batch can be over 60 minutes old.

Another important objective for Steve is to increase the breadth of data coming in. Flights tend to be seasonal, with a greater number heading to sunnier climates in the summer months, for example. There can also be geographical gaps — as the weather of Europe is largely determined by events to the west, it is crucial that airlines operating across the Atlantic are contributing. As such, Steve is targeting airlines in Iceland and the Azores to build up the observations profile. Since taking up his role, Steve has already signed up one new airline and is in conversation with a number of other operators.

Airlines can see the benefits straight away. They rely on meteorological information and predictions to operate safely, so are happy to play a part in contributing to richer, more in-depth data. Steve works with European meteorological partners on a day-to-day basis, sharing knowledge and expertise across WebEx and other portals. It's through this kind of collaboration that the world will gradually build an ever more accurate picture of global weather systems. "We couldn't survive or provide the services we do without global observations like these," explains Steve.

A vision for the future

All commercial aircraft have to take temperature and wind readings, but EUMETNET partners would value humidity readings too. However, to adapt an aircraft to take humidity readings is costly and time-consuming. It involves putting an inlet on the exterior of the aircraft, and sensors on the interior. In effect this means cutting a hole in the skin of an aircraft, which takes a lot of certification and design work before approval.

The best-case scenario would be where national federal aviation authorities bring in a ruling that all new aircraft have to be equipped to take humidity readings. Steve's vision is extremely focused: "We want to see all aircraft roll off the assembly line with the hardware and software already fitted to provide basic meteorological observations when and wherever the aircraft fly — irrespective of the airline."

Europe

A climate services project funded by the European Commission is focussing on understanding different markets and developing a select handful of prototype climate services, addressing the needs of specific users.

Market focus

The project, European Provision Of Regional Impacts Assessments on Seasonal and decadal timescales, known as EUPORIAS, is a partnership of 24 different organisations, businesses and national weather services co-ordinated by the Met Office.

It aims to bridge the gaps between users and provides of climate services. The project reached the end of its first year in November 2013 and is now entering a challenging and exciting phase.

To find out where and how climate information is used, and where there are gaps that need to be filled, the first phase established a stakeholder board of 75 public and private companies of various sizes. This involved carrying out and recording and translating lots of interviews.

The second exciting stage of the project has already begun researching and improving downscaling of climate models, evaluating climate impacts as well as examining how best to communicate uncertainty.

The final stage of the project which started in February this year is looking at how useful the information provided is to the end users. This will be achieved by developing a few prototypes of different ways in which seasonal and decadal information can be used.

The prototypes will be targeted at specific audiences, determined from the interviews conducted in the first phase of the project. The prototypes could be designed for any of the sectors that were involved in the interviews but will be made useful for specific users and decision makers.

EUPORIAS is an example of research which is a shift away from the research of the Intergovernmental Panel on Climate Change (IPCC), which is a review of all the peer-reviewed climate science literature. Instead, EUPORIAS seeks to address the needs of the Global Framework for Climate Services (GFCS) which aims to enable “better management of the risks of climate variability and change and adaptation to climate change, through the development and incorporation of science-based climate information and prediction into planning, policy and practice on the global, regional and national scale.”

By focussing on product development and understanding different markets, EUPORIAS is making sure that climate services are really relevant to users’ needs. As described on the EUPORIAS website, it is only relatively recently that we have been able to predict future environmental conditions. Now EUPORIAS intends to maximise the societal benefit of these new technologies.

Find out more at www.euporias.eu

EUPORIAS

Science profile

Dr Carlo Buontempo
Climate Hazard and Impact Processes Team Manager

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

After leading the Climate Adaptation team at the Met Office Hadley Centre between 2010 and 2014, Dr Carlo Buontempo is now leading the European Climate Service team. It's his role to develop new tools that help decision makers manage their climate risk portfolio.

Whether the end goal is to protect homes from flooding, to safeguard next year's harvest or keep the transportation systems in the UK running smoothly — an in-depth understanding of local climates and how they are changing is vital. That's exactly why Carlo and his team use regional climate modelling to develop scenarios for weather in specific regions, over defined timescales.

Developing climate scenarios at a regional level is no easy task — especially when the timescales they work with range from seasonal right up to decadal. There are a huge number of factors to consider. The weather, for example, can be greatly affected by the geography and topography of specific locations and this can change over a relatively small area.

Very precise information is critical — which is why Carlo and his team are constantly refining the tools and models they work with. Recent developments mean it's becoming possible to study regions more closely. And, as Carlo explains, his team are working on "initial runs of very high resolution regional models", meaning they can begin to study smaller regions in greater detail.

However, building climate scenarios is only one of the challenges Carlo's team faces. Ultimately, it's their role to help deliver better information to decision-makers in a range of organisations. But it's not always immediately clear to the decision-makers why detailed climate information could be useful. Part of Carlo's role is to outline the benefits of such data — and for this, he takes a very analytical approach.

"First we analyse their existing climate risk profile and look at the properties affecting it at present. Then we can ask how this might change in the future."

It's a persuasive process — and one that involves looking at how organisations may have reacted differently to recent severe weather if they could have drawn on more detailed climate information. The evidence usually speaks for itself and helps Carlo build a dialogue with policymakers from a wide range of sectors.

> "The great value in establishing relationships with other organisations…is that it gives a sense of transparency to what we do."

International collaboration

Carlo's work is not restricted to the UK. He makes Met Office technology available around the world through collaborative projects, the most recent being EUPORIAS, which you can read more about on the opposite page.

Back in 2009, another project took Carlo to Egypt, where he worked with a water resources organisation, DHI and the Egyptian Ministry for Water Resources and Irrigation (MWRI) to explore impacts of climate change on the Nile Basin. The project involved a host of challenges including the difficulty of studying such a diverse climate, which ranges from tropical rainstorms to desert conditions.

This variation of weather in the region meant it was possible to create only a statistical assessment of how the climate might change. The project ran one model that reproduced the present-day Nile climate as closely as possible, alongside another model used by the MWRI to assess water availability across the Basin. The use of multiple models in this way allows for a stronger prediction particularly, Carlo says, "in an area as complex as the Nile."

The project proved successful, not only in building knowledge of the Nile Basin's climate — but also in providing training that has enabled the various teams involved to continue developing climate scenarios using Met Office technology.

Breaking barriers

As well as international projects, Carlo explores ways to involve a wider audience in climate topics and, as he puts it, "break the barrier between the users and generators of climate information."

For Carlo, building relationships with non-scientific groups worldwide is an important way to create a "sense of ownership" of climate issues — to make people more aware of how climate affects them.

"The great value in establishing relationships with other organisations from different backgrounds, is that it gives a sense of transparency to what we do. This is one of our most important roles if we really want our information to trigger people's decisions."

Europe

Marine matters with Copernicus

Safety at sea, protecting aquatic ecosystems and securing marine resources are challenges faced around the world. The best way to tackle them, therefore, is through the co-ordination and collaboration of organisations in a range of countries. This is precisely why Europe's ambitious environmental monitoring programme — the Copernicus marine service — was born.

In homage to the 16th century scientist, Copernicus is the new name for the Global Monitoring for Environment and Security (GMES) initiative — developed in partnership by the European Commission and the European Space Agency. Copernicus will provide services for atmosphere (chemical composition), marine, climate change and land monitoring and services for emergency management and security. It will also support five types of Sentinel satellites underpinning these services. The marine services will draw on measurements of sea level, currents, ocean colour, sea surface temperature, wind and sea ice made from these satellites and in-situ sensors in the water some of which are operated by partner organisations. A group, including the Met Office, of 14 European institutions that have been leading the development of the marine service is aiming to play the leading role in delivering the Copernicus marine service, scheduled to start in spring 2014.

Working together

The Copernicus marine service will provide both real-time forecasts and analyses for the last 20 to 40 years calculated using historical data. This information will be used by national agencies and the commercial sector to help with a range of operations including ship routing, offshore operations, search and rescue, aquaculture and fisheries research. Information about the waves, sea ice and ocean temperatures will also feed directly into the Met Office's weather, seasonal and climate predictions. Dr Mike Bell, head of the UK's National Centre for Ocean Forecasting and Ocean Forecasting Research & Development within the Met Office outlines the motivation behind Copernicus:

"Europe wants to maintain a leading role in the satellites monitoring the environment as well as to ensure data that's expensive to generate is used effectively for operational services and to assess and improve the quality of climate change models."

Marine management

Copernicus also reflects a Europe-wide paradigm shift towards taking a more holistic approach to managing living marine resources. Ongoing monitoring and prediction will help us understand, for instance, the impact that river run-off with too many oxygen-sapping nutrients can have on biodiversity in our oceans.

Another example of how Copernicus encourages a sustainable marine ecosystem is fishing. By combining information on temperatures, currents and phytoplankton near the sea surface, the most suitable areas for fishing can be pinpointed and fishermen could be much more efficient with their catch.

Working within Copernicus and with other meteorological centres, the Met Office has explored how crucial surface wave models are for shipping and heavy lifting operations. The oil and gas sector are also affected by sub-surface ocean currents, which can damage the deep flexible pipes that connect the well-heads to the surface platforms.

Euro-Argo coverage

One of the partner organisations that provides sub-surface measurements is the Argo global ocean observing network. Since Argo was conceived in 1997, it has established a network of over 3,000 profiling floats spread across the global ocean. Each float follows a programmed schedule — descending 2,000 metres before rising to the surface every ten days, making temperature and salinity measurements that are sent via satellites to be analysed.

A major contributor to the international Argo programme is Euro-Argo. It began in 2008 and has increased the number of European countries contributing to Argo, which has led to enhanced coverage in the Nordic Seas, Mediterranean and Black Sea.

The importance of the Copernicus marine service becomes abundantly clear when you consider that 90% of world trade is transported by sea. From a European perspective, the sharing of best practice and co-ordination of information that Copernicus will provide is good news for the marine environment, as well as Europe's growth agenda for the future.

Major political events are sometimes shaped not just by people, but the weather too — says BBC World Affairs Editor John Simpson CBE.

Global witness

Having spent his entire career at the BBC, which he joined straight from University of Cambridge in 1965, John Simpson is synonymous with international political journalism.

From Nelson Mandela and Mikhail Gorbachev to Osama Bin Laden and Robert Mugabe, John's thoughtful, probing interviews reflect a 'Who's Who' of the most famous — and infamous — leaders of recent times. Getting the story has taken him to more than 120 countries, including 30 war zones.

"Travel and writing were both powerful influences when I was growing up," says John. "Over six years, my father, who ran away to sea at 15, travelled the world to India, Australia, the US and South America. The glamour of it all and his endless stories had a huge impact on me."

John's early BBC career saw him edit and present a foreign news radio programme based entirely on newspaper stories and phone interviews.

> "I've been in any number of places where weather has been a deciding factor."

"I never went anywhere of course," laughs John, now 69 but still travelling up to 14 days a month, "but it was a statement of intent. And I was made a foreign correspondent in 1971 — the BBC's youngest I think, although my great friend John Humphrys likes to say it was him!"

Tiananmen Square: things might have been different

"I've been in places where the weather's been a deciding factor," adds John. He recalls how a cameraman warned him of an impending storm a week before the 1989 student demonstrations in Beijing that ultimately led to hundreds of deaths.

"I foolishly said it would head elsewhere — but then found myself in one of the most violent storms I've ever encountered. People were hurled across Tiananmen Square by the wind for 40 to 50 yards and it was completely cleared of demonstrators."

John supposes if the Chinese Army had secured the area then, the subsequent confrontation and fatalities could have been avoided.

John has also seen how heat stirs people up. "Hot temperatures are a major factor in inflaming crowds," he says. "I've seen it in Baghdad — when anger boils over faster and things inevitably turn to violence — and again in Bangladesh."

Climate change: the evidence is no coincidence

But it was a series filmed for BBC World in 1997 that convinced John that it's not just the immediate weather, but also long-term climate change that cannot be ignored.

"We travelled to every continent excluding the Arctic and Antarctic — from Latin America to China, right across Europe and the US too," says John. "'Odd' weather was occurring in virtually every place we visited — and it really made me think."

As a seasoned political reporter whose career has been built on forensic analysis of the evidence, John not surprisingly takes the rational view.

"If you look at the graph post-1900 it would have to be the most amazing coincidence for rising global temperatures not to be linked to the internal combustion engine and industrialisation. To deny climate change really is to put your head in the sand."

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Australia wowed!

As an extension of the strong strategic relationship with the Bureau of Meteorology (BoM), the successful Met Office Weather Observation Website (WOW) is now being implemented in Australia.

The Australian version of the WOW site is aimed at all sorts of Australian users providing a range of different facilities for "citizen weather observers". People can submit weather related photos and manual and automatic weather observations, as well as being able to upload weather impact information such as flooding or wind damage.

This is the first time we have collaborated internationally to produce a variant of WOW designed specifically for use in another country. It is likely that more collaborations with other weather services and organisations will follow.

David Gooding from BoM said, "The Bureau immediately saw the benefits of collaborating with the Met Office on WOW. It's a well-thought out and designed system built on robust technology with modern mapping tools and adequate metadata to describe the source and its quality. We share the Met Office's vision that our hard work can now provide a template for other countries to effortlessly join the WOW partnership so the sharing of public weather information can take a global form."

Photo taken at Warrumbungle National Park. Alice Baker and James Gilbert.