barometer

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Met Office

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Forecasting for everyone

Quick and easy access to high quality forecasts and services from the Met Office helps UK Government agencies, and those overseas, prepare for severe weather by taking appropriate mitigating action, says Mark Hutchinson, Acting Chief Executive.

➔ **Mark Hutchinson**
Acting Chief Executive

The sheer power of weather had the Gulf Coast reeling from the force of Hurricane Katrina in August and Rita in September. The Met Office worked closely with the National Hurricane Center in Miami, as well as the UK Foreign Office and Embassies, to warn of this impending severe weather. The science behind hurricanes is explored further in Key Environmental Events on page 4 and we introduce our hurricane expert, Julian Heming, on page 16.

This year's Atlantic hurricane season was one of the most active and widely reported, and has given new impetus to the debate on climate change. With the increased likelihood of extreme weather events in future, the G8 nations have agreed to promote cleaner technologies to safeguard the climate. The Met Office is assisting by advising the UK Government on options for reducing greenhouse gas emissions post-2012, when the Kyoto Protocol has run its course.

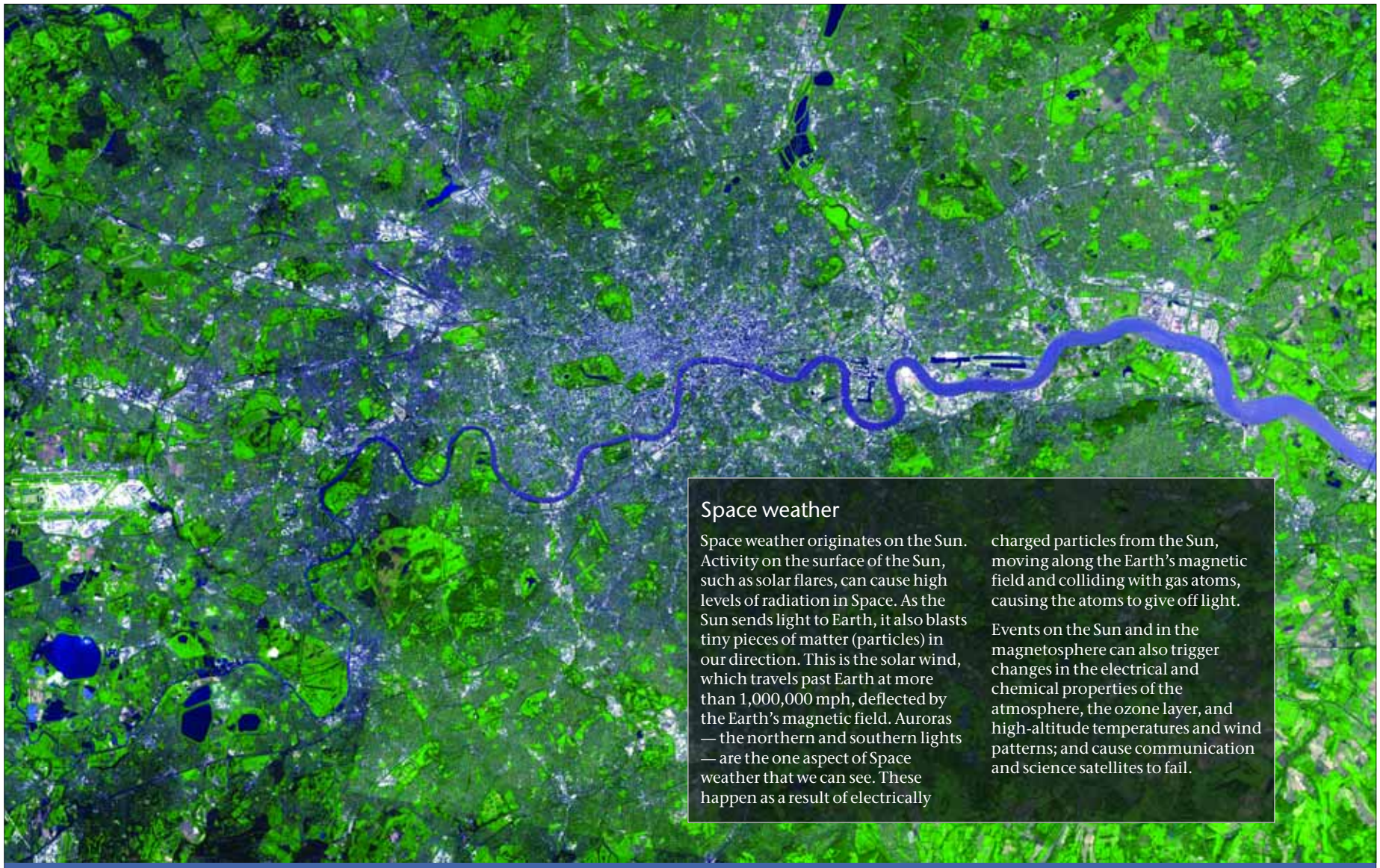
With a predicted colder-than-average winter expected, our forecasters are working closely with the National Health Service (NHS) and others to look after those who are vulnerable in cold weather. Targeted medical care (from NHS) and Warm Front grants (from Defra), triggered by timely and accurate forecasts from the Met Office, are working to reduce winter deaths and further the Government's aim to eradicate fuel poverty by 2018. Throughout the winter, we will be working closely with the Highways Agency and local authorities to help keep roads open and 'UK Plc' moving. Whatever the season, the Met Office works alongside Network Rail to help it tackle the complex problems posed by ice, high winds and other extreme events. *Barometer* looks at what is done, through this active partnership, to keep the railway network running smoothly in all types of weather.

At the Met Office, we are passionate about using our skills in meteorology in partnership with others to get the right weather and climate information to the right people at the right time. Recent advances in technology — including the internet and mobile devices — mean that people can now expect accurate weather information at their fingertips. Research shows that television weather sits comfortably alongside these new media. *Barometer* looks back at its evolution — from George Cowling's first live broadcast in 1954 to the new-look weather forecasts of the BBC and ITV — and at the challenge of making television weather broadcasts both informative and entertaining.

We mark the bicentenary of Admiral Lord Nelson's death by exploring how the weather influenced the British victory at the Battle of Trafalgar. As the modern battlefield can cover thousands of kilometres of land, air, sea and — increasingly — space, we also report on how the Met Office is working with the Ministry of Defence to provide instant access to the weather and environmental information that the contemporary military strategist needs.

As our customers' expectations grow, along with advances in technology, the Met Office will continue to improve its forecast accuracy. This year we have a more readily understood accuracy target which measures our next-day forecast for 11 UK cities. You can see how we are performing on our website.

I hope that *Barometer* will give you a flavour of the many different ways in which the weather touches all our lives. At the Met Office we are committed to using world-class science to predict the weather and climate for maximum benefit to the nation and to supporting other countries in their response to severe weather.



Space weather

Space weather originates on the Sun. Activity on the surface of the Sun, such as solar flares, can cause high levels of radiation in Space. As the Sun sends light to Earth, it also blasts tiny pieces of matter (particles) in our direction. This is the solar wind, which travels past Earth at more than 1,000,000 mph, deflected by the Earth's magnetic field. Auroras — the northern and southern lights — are the one aspect of Space weather that we can see. These happen as a result of electrically charged particles from the Sun, moving along the Earth's magnetic field and colliding with gas atoms, causing the atoms to give off light.

Events on the Sun and in the magnetosphere can also trigger changes in the electrical and chemical properties of the atmosphere, the ozone layer, and high-altitude temperatures and wind patterns; and cause communication and science satellites to fail.

What is out there?

Did you know that there are around 8,000 artificial objects orbiting Earth, 2,500 of which are satellites? So when you are wishing upon a star you might actually be wishing on a piece of metal.

The number of satellites in Space has risen as major advances in science and technology have been made, and in October these advances are celebrated as part of World Space Week. Set up in 1999 by the United Nations, World Space Week highlights the contribution that Space science and technology makes to our understanding of the world we live in.

Weather forecasting is just one of the many fields that has benefited from advances in Space technology — from tracking hurricanes to pinpointing rain clouds. But satellites are also used for a multitude of other reasons:

- The military — which was the first industry to use satellites — still relies heavily on data received from them
- Search satellites help save lives by watching for emergency beacons from boats and aeroplanes in distress
- The telecommunications and media industries use satellites to transmit signals around the world
- Remote-sensing satellites are used to detect changes in the Earth's surface and the environment
- Global Positioning Systems (GPS) are used for navigation on Earth — i.e. in your car or in an aeroplane

A modern view of the battlefield

The modern battlefield can cover thousands of kilometres of land, air, sea and — increasingly — space. But, as the UK's Armed Forces discovered this summer, there is now a way to view the entire battlefield using the Recognised Environmental Picture (REP).

Using a secure IT network, the REP gives frontline military strategists a full environmental picture of the terrain; and, earlier this year, the Met Office's contribution to the project was demonstrated at the Coalition Warrior Interoperability Demonstration (CWID). This is an annual event where certain international defence communities, including NATO, gather to demonstrate and evaluate technologies that will support the exchange of information on the future battlefield. Demonstrations are run as a 'virtual war' fought by a multi-national force in a fictional region of Africa.

At CWID, the Met Office demonstrated a new system that can present meteorological and other environmental information for any required area, whenever and wherever it is needed, regardless of the computer technology being used. The system — called the Joint Environmental Dynamic Data Server (JEDDS — as featured in *Barometer*, Issue 1) — took live data from the Met Office at Exeter and was able to feed them, on demand, to a number of the demonstration systems that were playing out the 'virtual war'.

Climate change explained

Climate change is always high on the political agenda — but never more so than this year when the UK holds the Presidency of the G8 and the European Union. Both have highlighted the need to improve public understanding of climate change.

The Met Office has teamed up with the Royal Meteorological Society to commission a DVD that will provide the facts about climate change. It is hoped that helping people understand the complex science that lies behind climate change will also help them make informed choices about tackling the problems it raises.

Leader and chair of the project's scientific steering group, Professor Paul Hardaker (the Met Office's Chief Advisor to Government), says: "I'm very excited by the potential impact that this DVD will have. Climate change often seems a big global phenomenon and it is hard for people to understand that they can make a difference at a local level, but they can."

➔ A number of bodies are already sponsoring the project. Interested parties can contact Professor Hardaker on 01392 886238 or paul.hardaker@metoffice.gov.uk

Being accurate

With weather as variable as the UK's, accurate forecasts from the Met Office are the first link in helping people be prepared. But as their expectations grow, the Met Office must keep up.

The first step in producing accurate weather forecasts is using all available observational data and putting it together in a computer forecasting model. The forecaster modifies the computer output as necessary to produce the most accurate, reliable and timely forecasts possible.

Last year the Met Office improved forecast accuracy for the northern hemisphere by around 11%.

This year, we have even more challenging Key Performance Targets (KPTs), one of which assesses the accuracy of our next-day forecasts for 11 cities across the UK. Our level of forecast accuracy will also be published on our website along with an explanation of why we may have got it wrong.

➔ The full KPTs are listed in the Annual Report and Accounts 2004/5 www.metoffice.gov.uk/bookshelf/annualreport/index.html

Staying warm

Keeping warm in the winter months is something everyone tries to do, and this winter people will need to do it more than ever, as the Met Office is predicting that it will be colder than average.

Since 1995–96, winters in the UK have been mild, giving many the impression that this is now the norm. Even an average winter could come as a surprise to many.

The Met Office helps support the Government's winter campaigns to protect lives during periods of cold weather by providing meteorological information, advice and forecasts via the Associate Parliamentary Warm Homes Group.

We also support the country's infrastructure by working closely with emergency planners in a number of agencies, who have received advance warnings about the seasonal forecast. In addition, the Met Office is backing npower and National Energy Action's *Spreading Warmth* programme which aims to help customers who are struggling to pay for energy use.

The force of Nature

Hurricane Katrina and Hurricane Rita were the most widely reported weather events of the year so far. On both occasions accurate and timely forecasts were provided through sophisticated modelling techniques.

Having crossed southern Florida as a category 1 hurricane, Katrina strengthened rapidly. For three days before landfall, forecasters at the National Hurricane Center (NHC) in Miami and local weather offices in the southern USA, worked around the clock to warn of the impending disaster.

Less than a month later Hurricane Rita was also heading for the southern states. Initially a category 5 hurricane, with wind speeds of more than 175 mph, Rita threatened to wreak even more devastation than Katrina. But as it reached landfall it began to reduce in intensity and was a category 3 as it swept through Texas and Louisiana. However, wind speeds of 120mph and a 10 ft storm surge left part of Texas and Louisiana severely damaged. Levees in New Orleans, which had previously been breached as a result of Katrina, were breached again.

The Met Office routinely provides input to the warning process by sending its forecasts of hurricane tracks to NHC every 12 hours. In the case of Katrina, Met Office forecasts three days ahead predicted the location of landfall to an accuracy of 60 km. During Rita's progress the Met Office also provided forecasts to the Foreign and Commonwealth Office; the Deputy Consul-General and Director of US Consular Operations; the British Embassy Washington and British Consulate-General in Houston. These accurately predicted the eastward shift of the hurricane. (See also Science Profile, page16).

Earlier in the hurricane season (June to November) Hurricane Emily hit Grenada, almost a year to the day after Hurricane Ivan devastated the island. It then moved on to Mexico, with wind speeds up to 135 mph. Meanwhile, in Taiwan, Typhoon Haitang injured 17 people as winds peaked at 114 mph and almost one metre of rain fell.

In the UK on 28 July a tornado, although small by comparison with the hurricanes, ripped through Birmingham with estimated winds of up to 130 mph, causing major damage and numerous injuries.

In July landslides and flash floods were caused by the heavy monsoon rains across India, especially hitting Assam and Arunachal. Thirty-five villages were affected and 10,000 people left homeless. Two months later, emergency services in Switzerland, Austria and Germany dealt with floods across alpine regions, which left hundreds of families homeless.

Drought conditions

Elsewhere it was drought and heat which affected people. In June, the Iberian Peninsula experienced the worst drought since the 1940s. Water reserves in Spain were just 57% of capacity, and farmers feared for their crops. By July, Spain was in the grip of its worst drought on record. Farmers in Murcia asked for permission to dig new wells to help save 80 million fruit trees.

In August Romania suffered a heatwave, which contributed to the deaths of 56 people. In China, while parts of the country suffered continuous flooding, in the east 7.6 million citizens faced water shortages.

Meanwhile south-east Australia experienced snowfall for the first time in decades, leading to schools and roads being closed.

In the UK the summer was a mixed bag — ranging from very warm to very wet. For example on 19 June, as London basked in temperatures of 33.1 °C, Hawnby, in North Yorkshire, had 60 mm (more than two inches) of rain in an hour.

Yet despite some heavy rainfall events, across the country the general picture was of a drier than average summer. In July, Scotland and Northern Ireland experienced well below-average rainfall. South East England and Central and Southern England have had the driest November to July period since 1975/1976. The driest area was Surrey, which received just 63% of its normal rainfall in that nine month period. However, there were some regional variations, with Scotland having considerably higher-than-average rainfall over the same period.

Battling the weather

Two hundred years ago, a British naval officer checked the weather, changed his plans accordingly and won one of the most famous sea-battles in British history. That officer was Admiral Lord Nelson and the battle was the Battle of Trafalgar.

The weather played a major role in the battle between the combined fleets of France and Spain, and the British Royal Navy. A light wind from the north-west influenced Nelson's decision to order the British to sail in two lines toward the French-Spanish fleet.

In a new tactic that defied traditional naval strategy, Nelson's ship — the Victory — sailed in the direction of the wind, leading a 'weather line' consisting of 11 British ships. The other 15 frigates from the British fleet made up a second, or 'lee', line led by the Royal Sovereign, and approached from the south-west.

Due to the north-westerly wind which prevailed all day on 21 October 1805, the French-Spanish fleet was unable to form a battle line and was slowly pushed northwards. Action began at Cape Trafalgar, off the Spanish coast, at around noon, when the leading British ships broke through the French-Spanish line.

An hour after the first shots, Nelson was fatally wounded by musket fire from the French ship Redoubtable and died a few hours later, but not before hearing that his battle plans had been successful. He was laid in state in the Painted Hall at the Royal Naval College, Greenwich in January 1806 once the British fleet returned home.

To mark the bicentenary of Nelson's death, the Royal Navy's Trafalgar 200 festival began this summer, with the largest International Fleet Review by Her Majesty Queen Elizabeth II. A total of 137 ships from the Royal Navy and 35 nations assembled off the coast of Portsmouth to commemorate Nelson — Britain's greatest naval hero.

Images © Crown copyright

The review included a re-enactment of the Battle of Trafalgar, involving 17 ships from five nations, and the biggest firework display ever seen in Britain. Just as on the day of Nelson's victory two hundred years earlier, the weather played a part, as around 250,000 soaked spectators gathered in the rain on the shore at Spithead to witness the centrepiece of the celebrations.

The Royal Navy's Trafalgar 200 festival was part of SeaBritain 2005 — a nationwide celebration of all things maritime. Fiestas were also held in Toulon, France and Cadiz, Spain in celebration of international friendship between former opponents.

Turning over a new leaf

Although we are renowned for being big tea drinkers in the UK, growing it has always been the preserve of hotter climes such as India and China. Now, for the first time, tea is being grown on a commercial basis here in the UK.

Britain's first commercial tea plantation has taken root on an estate in Cornwall, and is already proving to be a huge success. Although most people associate tea with the tropics, Jonathon Jones, Head Gardener at the Tregothnan Botanic Garden near Truro, and brains behind the new plantation, insists that growing a high quality tea in the British climate is not as challenging as some may think. In fact, tea is part of the camellia family, and Tregothnan has been renowned for growing camellias for hundreds of years.

"We started on a trial basis in 1999 and have been testing various tea plants to see which delivers the best results," he says. "It is mostly China tea, although we are running a trial of some Assam as well. The proof is in the pudding, and we are producing some very fine tea."

Good old British weather

Jonathon studied at the Royal Botanic Garden in Edinburgh and was appointed Head Gardener at the 60-acre private Tregothnan estate in 1996.

"One important thing to note is that this has nothing to do with global warming," he says. "You can grow tea even with good old traditional British weather, but Tregothnan does benefit from a microclimate which provides a longer growing season and mild winters, and contributes to the desired flavour of the tea.

"You can grow camellias virtually anywhere in Britain, but there is a big difference between keeping a plant alive and growing something that makes good tea. The growing season is long enough for us, particularly because we are not looking for volume but for high quality.

"We also have the right amount of tree cover and drainage thanks to the slopes. The growing areas are also generally south facing. It seems that being in valleys does help. But there are no absolute rights and wrongs about where tea will grow."

Thumbs up from tea expert

Tea expert Tim Tucker says the Tregothnan venture has every chance of success. Mr Tucker grew tea in India for the Eastern Assam Tea Company, from 1952 to 1961. He agrees Cornwall is the ideal place in the UK to grow a commercial crop but that such a venture is unlikely to succeed elsewhere in the country.

"Most of the common knowledge we have of tea is plain wrong," he says. "The geography text books say it grows best on a slope, but Assam — the highest yielding tea area in the world — is flat."

He adds that even quite severe weather will not kill off some of the more hardy varieties of tea: "Frosts don't matter if you have the right kind of bushes. The Assam bush, although higher yielding than the China bush, is more delicate and would not survive Cornish winters in the open. But the China bush — which I've seen survive heavy snow in areas such as the Caucasus in Georgia and on the Black Sea coasts of Turkey — could survive well in Cornwall. Unfortunately it gives lower yields and weaker brews."

Some of the most important factors, according to Mr Tucker, are acid soil, high humidity and, ideally, tree cover for the bushes. "The trees give a dappled shade and drop leaves, which helps to add nitrogen to the soil. One of the most important things is to get the distances between the bushes right. The aim when you are growing tea is to have a kind of lawn about waist high which gives continuous cover so that weeds can't grow underneath."

Concludes Jonathon: "The Tregothnan tea range is aimed at real connoisseurs and has been likened to a Darjeeling, which is considered to be the champagne of teas. That is the ultimate accolade."

Know your cuppa

- Tea is camellia sinensis, a selective of the camellia japonica. It is a bush about 10 feet high which grows in the shelter of other, bigger trees
- There are two main types of tea bush: the original China bush and the Assam bush (from north-eastern India). The native Assam bushes are now all hybrids, because they have cross-fertilised with the China bushes introduced into India
- Tea needs an acidic soil, and lime is harmful to it
- Tea, including green tea, always comes from camellias. Tea purists insist that all other herbal beverages should not be called tea, but 'tisanes'. A tisane is made with fresh or dried flowers, leaves, seeds or roots — but not with real tea
- The nearest tea production sites to Britain are in Turkey, South Carolina and the Azores
- Total world production of tea is 3,000,000 tonnes. The largest producers are Sri Lanka (20%), Kenya (19%), China (18%) and India (13%)

Wind in your sails

Being a TV weather presenter can have its peaks and troughs but, as **Phil Avery** soon found out, it is a breeze compared to sailing some of the world's most treacherous oceans.

From being battered by gales just outside Portsmouth to becalmed seas in the shadow of Table Mountain, Cape Town, Phil experienced all kinds of conditions while competing in the Global Challenge yacht race, sailing the 'wrong way' around the world against the prevailing winds and currents.

From day one, the weather put its stamp on the race, as Phil explains: "The first night out of Portsmouth was extremely rough with winds at gale force and driving rain. Yes, I was seasick!"

Setting off from Portsmouth on 3 October, 2004, 12 crews raced over more than 30,000 miles of ocean, passing through some of the world's most treacherous waters, before finishing 10 months later in La Rochelle. On the way, they stopped in Buenos Aires, Wellington, Sydney, Cape Town and Boston.

"We were very lucky to cross thousands of miles in the southern oceans with no serious injuries or encountering any of the very violent storms one can experience in those waters." says Phil.

Courtesy of onEdition

Stormy waters

The competitors experienced almost all possible sailing conditions, from the calm of the doldrums to the storms of the southern oceans; from icebergs en route for New Zealand to the tropical downpours along the east coast of Brazil. This, and the fact that they were participating in a sport that is totally dependent on the weather, made Phil a popular crew member.

"I know a number of skippers in the fleet were keen to have a qualified forecaster on board," he says. "Many of them are very competent at analysing weather information themselves, but it always helps to have someone on hand to take some of the responsibility for making important weather calls. I conferred with our tactician, Georgina Walker, on a daily basis; sometimes on a minute-by-minute basis in fast changing situations."

The crews constantly received meteorological data throughout their trip, and around UK waters relied on the Shipping Forecast issued by the Met Office on behalf of the Maritime and Coastguard Agency. Phil says his forecasting experience helped him identify the most important information quickly, helping to keep his skipper one step ahead of the changing forecasts.

As Phil puts it: "It paid to be the man on the ground with an eye to the sky. The race has also confirmed something I already knew — yachtsmen are among the most demanding of customers. An extra three or four knots of wind and a shift of 10 degrees seemed to be matters of life and death."

Life at sea

Phil had never taken part in anything like the Global Challenge race before, but he was no stranger to life at sea, having started his career as a forecaster in the Royal Navy, serving on HMS Ark Royal.

"The time onboard Ark Royal was sound preparation for going without so many of the things we take for granted in life and for living in close proximity with one's colleagues," he says.

Phil was born in Dunfermline, Scotland. After taking an Honours degree in Politics and Economics at Keele University, he served in the Royal Navy as a weather forecaster from 1984 to 1994. His broadcasting career began in 1996, first with The Weather Network and then The Weather Channel. He joined the Met Office BBC Weather Centre team in April 1998, and now broadcasts across all the BBC's domestic channels.

Courtesy of Challenge Business

Having finished the race — his team's craft achieving ninth place out of 12 competing yachts — he says he is now simply glad to be back on dry land. "The trip flew by in many ways. It certainly didn't feel like 10 months since we sailed from Portsmouth. Having said that, individual watches — particularly in the cold and wet of the Southern Ocean — did seem more like four years than four hours."

So would he do it again? "No! No! No! Life's too short," he says. "I have other ambitions for the future and would love to play a big part in presenting weather around the time of the London 2012 Olympics. Unless I'm competing, of course, at the tender age of 52."

"The first night out of Portsmouth was extremely rough with winds at gale force and driving rain. Yes, I was seasick!"

And now the weather...

The winds of change are blowing through the world of television weather forecasts. Although two big players — ITV and BBC — have gone down different routes, both have given their presentation a facelift, adding new life and spontaneity to broadcasts.

In 1954 George Cowling made television history when he presented the first live weather forecast. Lasting five minutes, it consisted of George showing weather charts that were hand drawn by him and Met Office colleagues.

Fast forward over half a century and everything has changed. TV weather forecasts, and those who present them, come in all shapes, sizes and frequencies. Met Office staff at the BBC produce 100 forecasts every weekday — for both UK and international channels — and there are more than 120 ITV national and regional forecasts daily, including live ITV News Channel interviews.

Producing so many forecasts — some are live and some pre-recorded — means that the presenters have to be on top of the story no matter where they are. But, as Becky Mantin — the latest addition to the ITV network — explains, it is not always that easy.

"One hot, sunny day last August, I was standing on a rooftop terrace waiting for them to come to me for a link during the news. Just as they ran a headline about an invasion of aggressive wasps affecting parts the area, I heard a low hum and a tickle at the top of my arm. Without thinking, I brushed at it, only to realise that I'd squashed the biggest wasp I'd ever seen. Then the pain kicked in and, at the same time, I heard in my ear 'coming to you in 5, 4, 3...' I did the only thing I could do — pulled the end of the sting out of my arm, looked up and started talking."

As her arm started to go numb, Becky explained her situation to her colleagues. But instead of sympathising, they decided to keep her waiting on the rooftop and come back to her shortly afterwards for her personal wasp story.

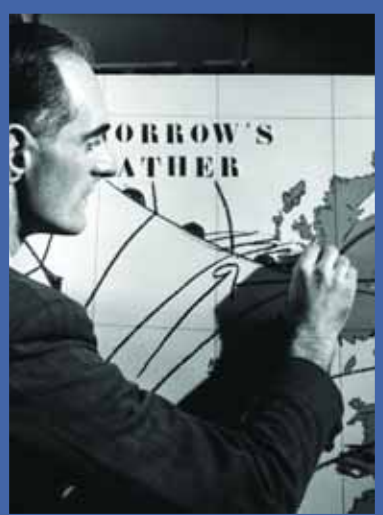
"All they said was 'Becky's been stung by a wasp. Fantastic timing!' and held over the weather for another ten minutes so it would fit the story! And I had just wanted to get the forecast over with as quickly as possible."

Live television

Live television, in a hurry, always brings problems as Helen Young, the Met Office's Lead Presenter at the BBC Weather Centre, explains: "I can remember one occasion when I was in the middle of a broadcast and one of my earrings fell off. There was nothing I could do, I just had to carry on. I did get a few letters from viewers who found it amusing. I'm just glad it was only an earring!"

Helen has also stumbled over her words on occasion — she once pronounced the name Fakenham incorrectly, while covering the weather for the day's races. Horses have also caused Helen's colleague Carol Kirkwood problems during a live broadcast.

She explains: "One winter in Devon, I was standing by a fence delivering a live weather forecast in fairly thick fog. Soon I was aware of some hot breath on my neck. I surreptitiously looked



The evolution of TV weather forecasts

1936 A weather chart is shown on BBC television — a world first. These early charts are hand drawn with wax crayons

1949 BBC television starts to broadcast captioned weather maps on a regular basis

1954 The first weather forecast featuring a live presenter on British television. George Cowling's (pictured left) broadcast lasted five minutes

1967 Colour television is launched, and the BBC introduces magnetic weather symbols stuck on wall charts — triangles for showers and dots for rain

1975 A new set of weather symbols is introduced, including a new cloud symbol. They provide a clearer and quicker understanding of essential forecast details

1985 Computerised symbols replace the magnetic rubber icons. Forecast computers at Met Office HQ are linked directly to a graphics computer system at BBC Television Centre. Moving satellite pictures are introduced

1988 New, more colourful graphics are introduced, showing the strength and direction of wind and rain

1989 First National Weather Bulletins across the ITV network. Powergen starts sponsoring ITV weather — the first time any TV programme has been sponsored in the UK

1996 New computer graphics include background maps with more topography and land shadings. More powerful computers allow forecasters to create forecasts more quickly and make greater use of sequences

2000 Computer 3D graphics are introduced into forecasts for the first time

2001 ITV weather goes 'widescreen' as 16:9 formats are introduced across the TV industry

2002 GMTV launches the first national 3D fly-through presentation using a Met Office graphic system

January 2005 ITV (24 hour) News Channel launches hourly weather bulletin and includes a daily live interview with the national weather presenter to cover topical global weather issues

2005 The complete redesign of BBC weather is launched, including TV, internet and digital text services. ITV relaunches a unified design across all national and regional bulletins

Courtesy of the BBC Weather Centre

around, only to find a horse's head alongside mine. So as not to startle the horse and risk being bitten (or worse), all I could think of saying to him was 'now you stay there'. In my ear I could hear the Gallery howling with laughter, which made it nigh on impossible to keep a straight face."

Again, like Helen, she had to ignore the laughter and interruption and carry on. Being alone, either in the studio or on location, means presenters only have themselves to rely on.

However, they also know that, when it comes to the actual weather story, they can always rely on experts at the Met Office to provide them with as much information as possible. One constant throughout TV weather history is the fact that the Met Office still provides the majority of television weather information in the UK.

Powerful computers

As weather data comes in from the Met Office in Exeter they are held and updated on databases at the BBC and ITV so that all weather output is consistent. While the Met Office forecasters use powerful computers to create the forecasts, central computer servers at the BBC transform the data into 3D images. At ITV, the presenters are briefed by Met Office forecasters who have worked with graphic designers to produce the forecasts in a similar way. Across the board, major technological advances have made the presenters' job easier, quicker and more efficient, enabling them to present the weather story in a language and format that viewers understand.

Helen explains: "Thanks to things like webcams I can now show viewers live pictures of what the weather is actually doing in their areas; and thanks to the latest computers I now have masses of information literally at my fingertips. Having forecasters on top of the weather story is vital to ensure we warn the public about any dangers and also give them the good news, when it happens. Therefore having cutting edge systems and equipment which makes this possible is also essential."

ITV regional presenter Jon Mitchell agrees: "When I first joined in 1989, my predecessor had been using a turning cube with four faces, so he was limited to only four weather maps. He was also using a synoptic chart with isobars and magnetic strips. It took a huge amount of time to compile these. Although we had a computer putting symbols on a map, the whole system was very cumbersome. We used to get photographs sent over on a fax. We would take a picture of them with our camera and overlay that onto the graphics. Now, of course, we get a digital picture directly from the satellite."

Disappearing presenters

The advent of chroma key technology — the removal of a colour (or small colour range) from one image to reveal another 'behind' it — it has led to presenters looking directly at the camera, instead of behind them at the weather map.

In fact, if they do look behind them all they will see is a blue or green screen — the weather map is not actually there at all. This is added digitally once the background colour has been removed. Presenters do have a faint outline of the weather map to guide them through their broadcasts, but rely on a monitor hidden off-camera to give them the complete picture.

Blue has traditionally been used as a background colour because it is complementary to human skin tone and is therefore easier to remove digitally. However green screens are increasingly being used as the colour has become easier to remove and is not found as frequently on clothing. It is essential that presenters do not wear clothing of a similar colour to the background screens because their clothing, or part of it, will automatically be rubbed out as well — basically parts of them will disappear.

Changes in technology over the years have also changed the styles of the presenters. They now have much more freedom to add to the basic weather story, as Becky explains:

"It is not just that the graphics have changed. There has been a move towards presenters having more input into the broadcasts. After all, it is supposed to be a source of information and entertainment for people. Adding in 'how the weather is going to feel' or environmental factors makes it much more of an informative bulletin."

All change

From leaves on the line to rails buckling in the heat, every change in the weather creates a new challenge for Network Rail, the people responsible for keeping the country's railway network running smoothly.

Anyone who travels by train knows how frustrating it can be when services are late or cancelled, but many of us do not realise the amount of work that goes on behind the scenes to make sure everything runs as smoothly as possible. It is also hard to appreciate just how complex some of the problems can be — especially where the weather is concerned.

Working forecasts

Most types of extreme weather can cause problems for the rail network. For example, ice can cause problems in areas where the electrical current is on the ground, such as around London or on Mersey Rail.

"We use Met Office forecasts to decide whether we should send the de-icing trains out or not," says Steve Scott, the National Weather Strategy Manager for Network Rail.

"Ice is difficult to remove, so these days we try to be proactive and prevent it forming in the first place. In high winds we can have problems with overhead electrical power lines and high station roofs. Even vegetation can create difficulties, such as when trees come crashing down. Sometimes the trees are not growing on our property, which makes them doubly hard to deal with in advance."

Hot weather comes with its own set of difficulties. Heat makes metal expand, so very hot days can lead to distortion of the track; while prolonged dry spells can lead to line-side fires and possible damage to line-side equipment and cables.

Rain or shine

The weather can create so many different problems for Network Rail that it has a special team to minimise the impact on the country's railway network. Every morning it receives a five-day forecast from the Met Office, targeted at 32 local areas and identifying potential risks to the network from various weather hazards.

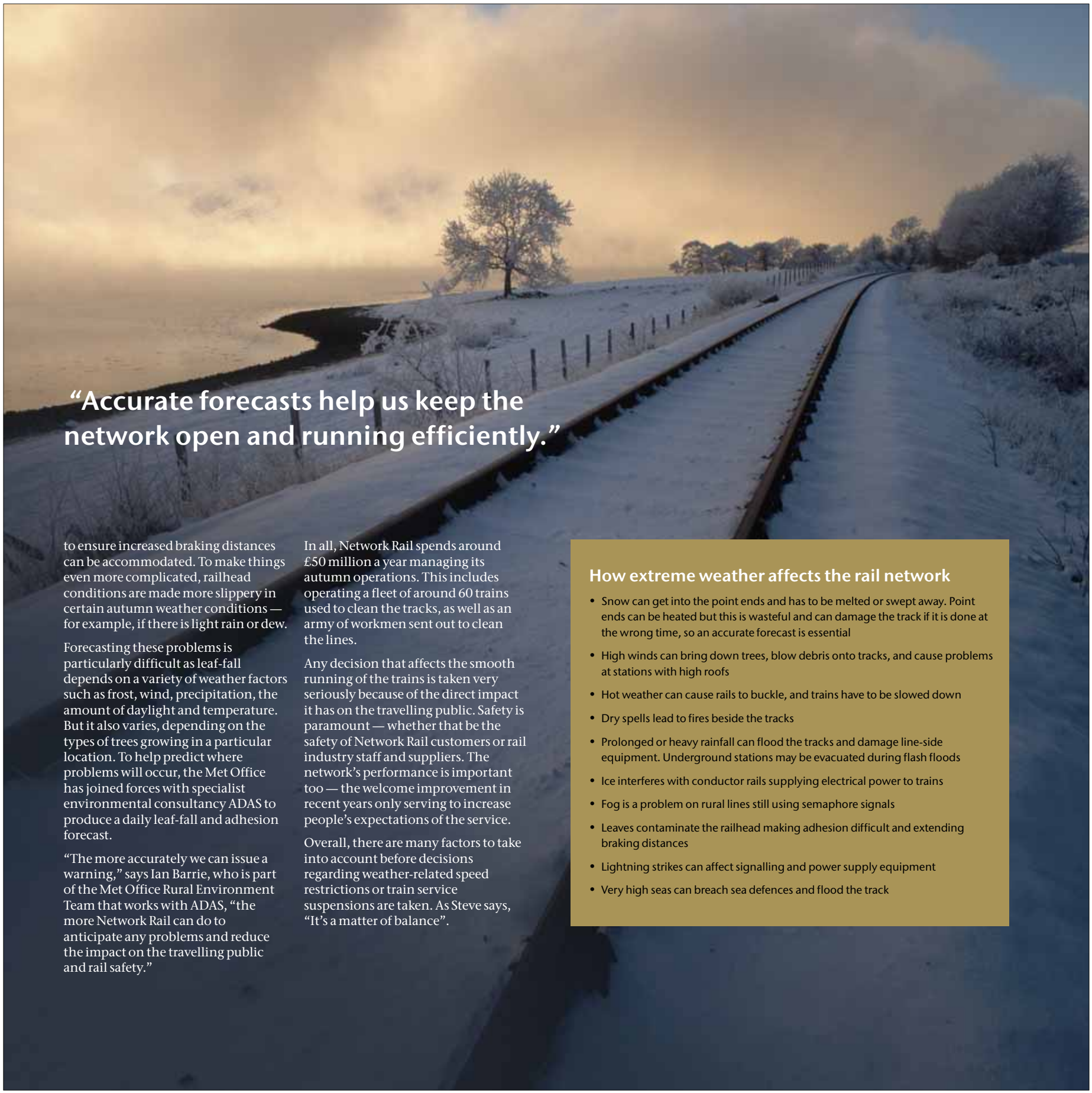
"Accurate forecasts help us keep the network open and running efficiently, and that is really important for our passengers," says Steve. "Weather can cause up to 10% of all delays across the network. Three-quarters of these usually happen from October to March, mainly because of leaf-fall, increased wind speeds and cold temperatures."

Leaves on the line

At this time of year, the autumn leaf-fall period brings with it a unique set of problems.

Says Steve "If you think forecasting the weather is a challenge then forecasting adhesion conditions on a rail track is another level of complexity altogether — particularly in the autumn when leaf-fall is at its most prevalent."

Leaf-fall can lead to trains having problems with accelerating and braking. Train drivers must also adjust their driving style to the more difficult conditions with the potential knock-on-effect of causing train services to lose time. In extreme circumstances, a modified form of signalling may have to be introduced



“Accurate forecasts help us keep the network open and running efficiently.”

to ensure increased braking distances can be accommodated. To make things even more complicated, railhead conditions are made more slippery in certain autumn weather conditions — for example, if there is light rain or dew.

Forecasting these problems is particularly difficult as leaf-fall depends on a variety of weather factors such as frost, wind, precipitation, the amount of daylight and temperature. But it also varies, depending on the types of trees growing in a particular location. To help predict where problems will occur, the Met Office has joined forces with specialist environmental consultancy ADAS to produce a daily leaf-fall and adhesion forecast.

“The more accurately we can issue a warning,” says Ian Barrie, who is part of the Met Office Rural Environment Team that works with ADAS, “the more Network Rail can do to anticipate any problems and reduce the impact on the travelling public and rail safety.”

In all, Network Rail spends around £50 million a year managing its autumn operations. This includes operating a fleet of around 60 trains used to clean the tracks, as well as an army of workmen sent out to clean the lines.

Any decision that affects the smooth running of the trains is taken very seriously because of the direct impact it has on the travelling public. Safety is paramount — whether that be the safety of Network Rail customers or rail industry staff and suppliers. The network’s performance is important too — the welcome improvement in recent years only serving to increase people’s expectations of the service.

Overall, there are many factors to take into account before decisions regarding weather-related speed restrictions or train service suspensions are taken. As Steve says, “It’s a matter of balance”.

How extreme weather affects the rail network

- Snow can get into the point ends and has to be melted or swept away. Point ends can be heated but this is wasteful and can damage the track if it is done at the wrong time, so an accurate forecast is essential
- High winds can bring down trees, blow debris onto tracks, and cause problems at stations with high roofs
- Hot weather can cause rails to buckle, and trains have to be slowed down
- Dry spells lead to fires beside the tracks
- Prolonged or heavy rainfall can flood the tracks and damage line-side equipment. Underground stations may be evacuated during flash floods
- Ice interferes with conductor rails supplying electrical power to trains
- Fog is a problem on rural lines still using semaphore signals
- Leaves contaminate the railhead making adhesion difficult and extending braking distances
- Lightning strikes can affect signalling and power supply equipment
- Very high seas can breach sea defences and flood the track

At the magnetic pole

The pull of the Pole

For 13 days three British women pitted themselves against the harshest elements Nature could throw at them to become the first all-female team to successfully complete a gruelling polar race.

Hauling sledges weighing almost twice their body weight, enduring temperatures as low as -40 °C and trekking across constantly shifting sea ice, the women succeeded where others had failed, by completing the Scott Dunn Polar Challenge.

On 22 April 2005, The Pink Lady Polecats — Felicity Aston, Sam Eve and Tori James — left Polaris Mine in the Canadian North West Territories. Three weeks and 368 miles later they crossed the finishing line at Magnetic North Pole in sixth place — out of 16 teams — and made race history as the first female team ever to finish the race.

The three hardy adventurers — Felicity, 27, Sam, 26, and Tori, 23 — met while working for BSES Expeditions (formerly The British Schools Exploring Society). Having already taken part in a variety of smaller expeditions, they were keen to test their skills to the limit. But, as meteorologist Felicity explains, this was not the only reason they went. They also wanted to highlight the issues of global warming and climate change.

“The impacts of climate change are going to be seen first in the Arctic and Antarctic, and most people don’t know much about these places,” she says “People need some sort of connection with areas in order to feel they are important. We have that connection because we have been there, but not everyone has that chance. We hope that by taking part in this race, we have helped make these regions more real to more people.”

This was not Felicity's first experience of cold climates. After studying physics, astronomy and climate change at university, she joined the British Antarctic Survey as a meteorologist, becoming only the ninth woman to spend a winter at the Rothera Research Station, on the Antarctic Peninsula. She has also been on expeditions in Greenland, Canada and South America.

However, the Polar Challenge was a far cry from any of her previous experiences of freezing temperatures. She explains: "What I did in Antarctica was very different. We'd usually have a warm building to go back to and we took spares of everything, because we were the only people out there and could not risk anything going wrong. In the race it was a very different matter. You took a minimum of everything and threw out anything that wasn't absolutely essential."

Knowing that their bodies would be pushed to the limit — having to endure days of arduous trekking in extreme conditions — the women undertook six months of intense fitness training. This included three-hour gym sessions, three or four times a week, and dragging car tyres cross-country to simulate the action of hauling a heavy sledge over the ice. The girls also had to change their eating habits in order to achieve their physical potential, which meant eating a lot of brown rice, nuts and fruit.

Before they started the race they worked out their strategy. Felicity says: "You have to have a definite idea of how many miles you want to do in a day, roughly how many hours you want it to take you and what sort of pace you want to set. The sitting down and talking about tactics and strategy is really important."

And it seems that their strategy — and the fact that the women kept each other going through pain, cold, hunger and fatigue — worked.

Felicity says: "When we get together there is a real buzz; a strong feeling of camaraderie. We all had a singular goal — to finish the race — and it was great to share that. The sense of achievement when we crossed the finishing line together was just enormous."

Polar challenge fact file:

- Start: Polaris Mine, North West Canadian Territories
- Finish: The 1996 Certified Magnetic Pole position (Isachcsen Mine)
- Date: 22 April 2005
- Duration: 3 weeks
- Distance: 368 miles (approx. 20 miles/day)
- Load: A sledge weighing more than 60 kg containing equipment and supplies
- Temperature: From -20 °C to -40 °C on a good day, down to -70 °C with wind chill
- Terrain: Between 0–600 m elevation over frozen sea ice and land
- Food: Dehydrated rations
- Water: Melted snow and ice
- Risks: Frostbite, polar bears and dehydration
- Support: Meteorological information, satellite phones, flares, rifles and personal locator beacons. Additional ground crew support (including a doctor) at checkpoints, base camp and on skidoos

For more details, visit www.polar-challenge.com

A golden age

A recent World Meteorological Organization meeting in Prague claimed that we are entering a golden age for weather satellite data. **Stephen English**, Satellite Radiance Assimilation Manager, examines whether this is true and what it means for the Met Office.

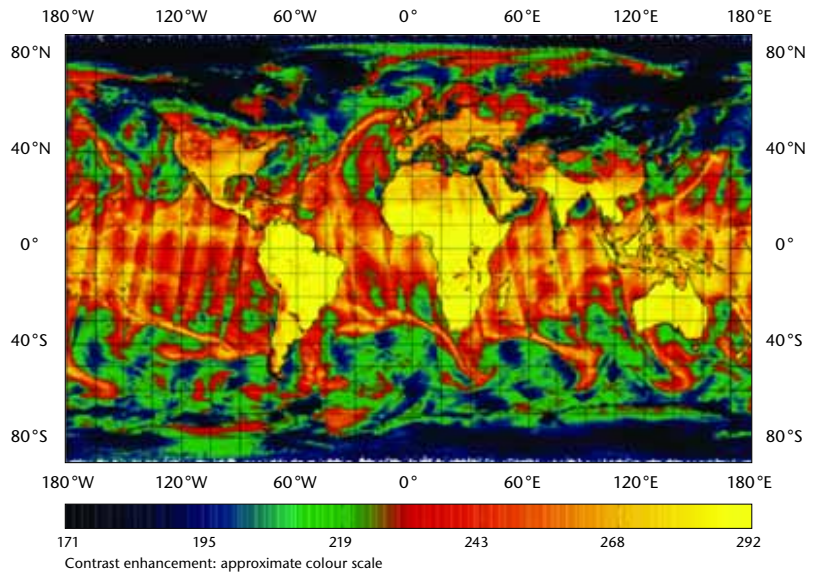


Figure 1: AMSU-B 89 GHz image showing variations in water vapour over the ocean (blue areas are very dry over the ocean and orange and yellow are very moist) and snow cover over land (blue and green areas are deep snow cover over land)

On 13 October 1959, meteorological history was made when pioneering American scientist Verner Suomi fixed a camera to a satellite and showed the world a new way of looking at the weather. Since then, the amount, quality and importance of satellite data have been increasing.

There are two main types of satellite. The first — the geostationary satellite — looks continuously at the same area of Earth. Five of these are needed for a constant view of the entire planet and to produce the movie loops of clouds often seen on TV broadcasts. The second type orbits the planet. By using three of these we can revisit the same view four or five times a day. These polar orbiting satellites provide information on upper atmospheric temperature and humidity, which change relatively slowly with time.

Onboard satellite instruments measure three bands of light: visible light we can see, infrared and microwave. The advantage of microwave light is that it passes through clouds so we can 'see' below clouds from space.

Increasing impact of satellite data

In the early days of weather satellites the measurements were not particularly accurate and were limited in what they could achieve. Also, weather forecasting centres did not have sufficiently well-developed systems nor sufficient computer power to process effectively all the data for operational weather forecasting. As information derived from satellites became more sophisticated their impact on weather forecasting began to increase.

Subsequent improvements in technology led to even more accurate measurements. An example from the Advanced Microwave Sounding Unit is shown in **Figure 1**. This unit provided an unprecedented quality and quantity of information on temperature and humidity, but still the satellites only measured 40 channels (narrow bands of light, mostly microwave and infrared). This type of satellite data has been available for many years and provided freely to forecast centres — including the Met Office — by NOAA, the American national weather service.

In 2002, NASA launched a new infrared research instrument called the Atmospheric Infrared Sounder, which measures more than 2,000 channels. This increase means that, for the first time, changes in temperature of 1 °C can be resolved in layers 1 km thick (previous systems could only resolve changes in 3 km thick layers). These fine structures in temperature with height are important for predicting the weather. The Met Office implemented a system to use this NASA research data operationally in May 2005.

The METOP satellite

In 2006, similar infrared data will become available on METOP, the first in a series of European operational polar orbiting satellites, operated by

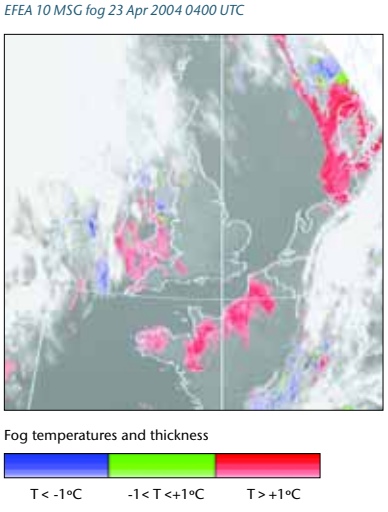


Figure 2: An image over the British Isles showing where fog is occurring (coloured areas). These images are generated at night and are valuable for aviation and traffic forecasts

EUMETSAT — the European Organisation for the Exploration of Meteorological Satellites. The UK is a major contributor to METOP and will benefit from the data. METOP also continues the important microwave component of the satellite observations which, unlike the infrared component, provides temperature and water vapour information in and below clouds, and will remain important for numerical weather prediction (NWP) for many years to come.

The benefits will keep growing

The arrival of the first METOP satellite will build on the existing European contribution to geostationary satellites which was most recently advanced through the launch of the Meteosat second generation (MSG) satellite series in 2002. Together, METOP and MSG will deliver benefits in a range of areas, including NWP, cloud imagery, fog imagery, environmental products (e.g. volcanic dust), rainfall products and climate monitoring. An example of a fog image from MSG is given in **Figure 2**. These fog products are available every 15 minutes from MSG (prior to MSG they were only available on polar orbiting satellites two or three times a day).

METOP is a 15-year programme, during which we will continue to learn how to use the data more effectively. Initial efforts will focus on using microwave data to maintain existing capability, with data from the other instruments exploited shortly afterwards.

We have already come a very long way. The impact of satellites on weather forecasts is now reported to exceed the impact of non-satellite data. However, it is clear that the quality and quantity of satellite data will continue to grow. The challenge continues to be to fully exploit the potential of this golden age for satellite data in meteorology.

Science profile

➔ **Julian Heming**
Tropical Prediction Scientist

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

Julian Heming is the UK's top 'storm chaser', but instead of flying into the eye of tropical storms and cyclones he tracks them from the comfort of his desk at the Met Office in Exeter.

There are few sights more awe-inspiring than a hurricane at full force, and the scenes of destruction it leaves in its wake are always quick to hit our TV screens.

Hurricanes occur between June and November in the Atlantic and parts of the Pacific Ocean. They can also form off the coast of Australia and in the Indian Ocean between November and March.

Although the devastation speaks for itself, the science behind hurricanes needs more explanation, which is why Met Office scientist Julian Heming is often called upon to present on radio and TV. As one of the nation's foremost specialists on tropical cyclones he is a long-standing favourite with the media. When Hurricanes Katrina and Rita left their trails of destruction, Julian found himself in demand by everyone from the BBC to CNN. But appearing in the media does not faze him because, as Julian explains, his media training began while still at school.

"I did my first media interview when I was 13," he says. "It was on local radio, on a Saturday morning children's slot and I had to answer questions about the weather fired at me by the show's hosts. Now I do a lot of media work during active periods of the hurricane season in the Atlantic. It can be a busy time, but at least I learnt the skills early on."

Montage of satellites images of the track of Hurricane Isabel. Courtesy of NOAA

A tropical debate

Julian studied Physics and Meteorology at Reading University before joining the Met Office in 1988. Here, he specialised in looking at ways in which forecasters could improve computer weather models.

Julian's early career led him to work on tropical weather conditions, collaborating closely with Professor Johnny Chan of City University, Hong Kong. Using new techniques for intervening in prediction models by introducing 'synthetic' or 'bogus' observations, Julian helped develop ways to deliver better information on how tropical cyclones will develop and in which direction they will move.

Tropical cyclones happen when trade winds in the tropics (both north and south of the Equator) converge at low level over the ocean. Warm sea temperatures lead to moisture being pushed up until it forms clouds. If various atmospheric conditions are right, these clouds grow and start to rotate. The term tropical cyclone is used to describe all such revolving storms. If the sustained winds are greater than 74 mph they are then also called hurricanes (in the Atlantic and eastern North Pacific) or typhoons (in the western North Pacific).

This year's model

These new techniques were first put into action in 1995 — one of the most active years for Atlantic hurricanes on record. "In one fell swoop we reduced the hurricane forecast errors by 30%," says Julian. "The Met Office model outperformed all others around the world that year and soon forecasters from other countries such as the USA wanted to see Met Office forecasts to aid them in forecasting tropical cyclones for their local area."

Since 1995, Julian has been working on continuous improvements and refinements to the model. He is also involved in long-term research projects; collaborating with fellow scientists and forecasters around the world; checking that the tropical cyclone systems work; producing reports and carrying out verification of forecasts.

Julian's work also involves researching and predicting monsoons, and cyclical phenomena such as the Madden-Julian Oscillation (a pattern of tropical rainfall). But, predictably, it is his work with hurricanes that gets him all the media attention.

A drop in the ocean

Sea-surface temperatures are an important part of day-to-day weather forecasting and point to how the climate is behaving. But with 70% of the Earth's surface made up of water, how is the temperature of the sea accurately measured? Met Office scientist **Craig Donlon** explains.

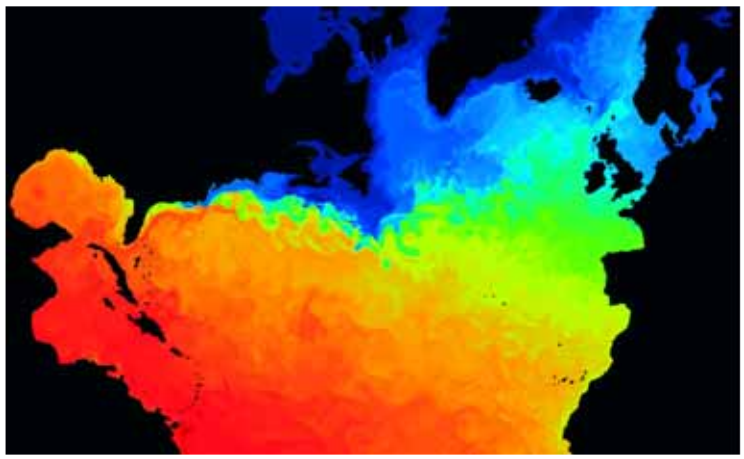


Figure 1. Sea-surface temperature from North Atlantic FOAM at 1/9 degree resolution showing details of the mesoscale structure

The sea-surface temperature (SST) is an essential measurement for all weather and ocean forecasting models and is used by the Met Office each day.

SST helps forecasters to predict everyday offshore hazards such as fog — helping sailors make the most of their leisure time and shipping companies plan the safe passage of perishable cargo.

Increasingly, wind farms in coastal areas rely on SST and predictions of sea breeze activity from the Met Office in the move towards renewable, environmentally-friendly sources of energy.

The aviation industry too needs high resolution SST maps to identify warm water areas that may trigger cumulonimbus activity — a real danger to all aircraft.

Studying this data is also of great importance for climate researchers as the ocean has a long memory thanks to its high heat capacity (the heat content of the top three metres of the ocean is equal to that of the entire atmosphere above).

But on a planet that is more than 70% ocean we would need millions of thermometers to provide an accurate and complete global map of SST.

Taking the temperature of the ocean

In fact, there are thousands of surface drifting buoys and moorings which measure SST and report back to the Met Office several times a day, and many ships take meteorological measurements for us. However, all of these observations — which measure SST using 3 mm diameter temperature sensors — are just a drop in the ocean because enormous areas such as the wild seas of the Southern Ocean are not measured at all.

This is where satellite imaging helps, by providing millions of measurements every day over the entire global ocean.

Since 1962, when the first satellite imaging system (TIROS-N) returned pictures of the Earth, the skills of meteorologists and oceanographers around the world have been revolutionised.

In the early days, achieving an SST accuracy of better than 1°C from observational equipment in space was a great achievement, but today this is way off the mark. The most accurate system in space today is the European Space Agency's Advanced Along Track Scanning Radiometer (AATSR), funded by the UK's Department of Environment and Rural Affairs. The AATSR is able to measure the SST to an accuracy of better than 0.2 °C from over 800 km above the ocean surface, which is better than most of us could achieve with a thermometer in the bath. But how does the AATSR instrument work?

The AATSR measures the infrared energy emitted from the sea surface of the ocean just like the heat from an electric fire, but at a lower temperature. As it flies forward in an orbit around the Earth, the AATSR scans across the sea surface to build up an image of the SST. The measured signals are calibrated using a sophisticated onboard system, then geo-referenced so that a map of SST is generated.

Aerosols — from volcanic eruptions, large dust storms and forest fires — are a major challenge, as they are present in the atmosphere and depress the measured SST by absorbing infrared radiation. To overcome the aerosol problem, the AATSR uses a unique and innovative technique which measures infrared radiation from a forward and vertical angle. By combining these observations, the AATSR is able to compensate for atmospheric aerosol effects.

Stitching together the big picture

But even satellite observations of SST are not able to measure the entire global ocean every day. The only way to do this is to combine all available measurements and a new, collaborative project at the Met Office — called the Operational SST and Sea Ice Analysis (OSTIA) — is doing just this, by generating a global analysis of SST using only the best quality observations from satellites, ships and buoys. The AATSR is an essential input to the OSTIA system.

The future

Future European satellite systems are now being developed to replace the current set of instruments in space. The European Space Agency Sentinel-3 series planned for 2011/2 is particularly important as it will carry a next-generation AATSR system.

So, next time you are flying, think of the satellite systems that are tirelessly measuring SST and the forecasters supporting your pilot by providing the weather, ocean or seasonal forecasts for your destination. And remember, the weather and climate over our country today is, in part, determined by the distant and 'forgotten' ocean temperatures of some time ago — which can only be measured effectively from space.

Chris Bonington on Elbrus in Russia in 1993

Chris Bonington

Everest, K2, the Eiger... places that are distant dreams for most people are places where Sir Chris Bonington forged his career. As one of the country's most famous climbers, his life's work is inextricably linked to the elements. So is the weather friend or foe?

There are few environments that put people at the mercy of the elements more than the mountains, where the weather can change in moments and the results can be catastrophic. Chris discovered this at an early age on his first trip to the mountains of North Wales.

Born and raised in London by a family who showed little interest in the mountains, the source of his passion for peaks is mysterious. But, as a 16-year-old, his fascination led him to persuade a school friend to take a trip to Snowdonia in the Christmas break for their first taste of mountaineering.

With very little equipment and even less experience, Chris and his friend took themselves up Snowdon, blissfully unaware of the danger they faced.

Chris explains: "I am sure we should have been warned off Snowdon, for in severe winter conditions even the easiest way up can be dangerous and has claimed lives."

Part of the way into the ascent, the heavy snowfall made progress very treacherous. Chris continues: "Suddenly, everything around us was moving and we rolled and slid in a steadily moving chute of snow down the slope. We had no real comprehension of danger, and arrived at the bottom laughing."

If the conditions put his friend off mountains for good, they did little to dampen Chris' passion. He was hooked and spent every spare moment dreaming of the mountains and planning his next trip.

Career peaks

The list of achievements that followed these early exploits is impressive. From his ascent of Annapurna II in Nepal in 1961; through leading many expeditions up awe-inspiring peaks such as Everest; to making the first ascent of Danga II in East Nepal with his son, brother and nephew in 2000; Chris' life has always followed the path of adventure. In a career spanning more than 45 years he has earned many accolades including a CBE in 1986 and knighthood in 1996.

During so many years at the height of one of the world's toughest sports, he has developed a close relationship with the weather, but even in the early years he had a feel for its patterns and whims. One memorable climb for Chris was the 1962 ascent of the Walker Spur in the Grandes Jorasses in Chamonix, France, with Ian Clough.

"We bivouacked at the bottom of the climb and were one of several parties ready to climb the next day, but there was high cloud in the morning and eight other parties turned back. Ian and I thought it looked okay and started our ascent. By 11am the skies were clear and we had a fantastic climb. Three days later we climbed the North Wall of the Eiger [one of climbing's most formidable challenges at the time]. In climbing you need to listen to your hunches."

Feeling and forecasting

But Chris has also been caught out by the weather and knows the importance of heeding the signals. "People can get too focused on finishing their climb and ignore the signs. It's very important to be sensitive to all the warnings."

So for Chris, judging the weather is a combination of "feeling and forecasting" and he maintains that you need both. Over his years as a climber he has seen forecasting change dramatically. "In the 1960s we used to get specific reports from the local area on regular forecasts for the Everest region. Along with statistics and past reports of the weather, we had enough information on which to base our decisions. But now, it's incredible. You can get accurate reports, no matter where you are in the world. It's definitely made planning expeditions easier."

Spirit of adventure

The passion that Chris feels for the mountains and climbing shows little sign of abating, and recent trips have including Ireland, Morocco, India and a return to Thyangboche, a small monastery in Nepal with dramatic views of Everest.

It seems that climbing is in Chris' blood. When asked what he would be doing if he had not become a mountaineer he simply reiterates the title of his first book: "'I Chose to Climb', and that is that."

➔ For more info on Sir Chris Bonington visit www.bonington.com. For info on mountain safety visit www.met office.gov.uk

Crosby, chills and splash

You need an iron constitution to brave the beach all year round, especially if you are exposed to the elements. Luckily, an iron constitution is exactly what 100 figures on Merseyside's Crosby beach have. Facing every weather condition the UK can throw at them, the cast-iron sculptures by Angel of the North creator Antony Gormley, will gaze out to sea for the next year.

Moulded from his own body, the sculptures have previously stood in a river estuary in De Panne, Belgium, in 2003; on the shores of Stavenger in Norway in 1998 and at Cuxhaven in Germany in 1997.

Says Gormley: "The seaside is a good place to do this. Here time is tested by tide, architecture by the elements."

More than 600,000 people are expected to visit the project, which has cost £150,000 to install and could generate £5m for the local economy.