



Ecosystems and climate impacts

Rainforests can make it rain and help to maintain their own climate. Thick forests keep it cooler and wetter and recycle water. In the Amazon basin there is a significant recycling of water across the South American continent. To understand what is happening, we need to look at the whole effects of global warming and take a holistic view.

Climate scientists have also made some important and surprising observations, which the world community will need to take into account when planning how to deal with climate change. For example, they have demonstrated that planting forests to slow global climate change is not always a good idea.

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barometer

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STORM WARNINGS

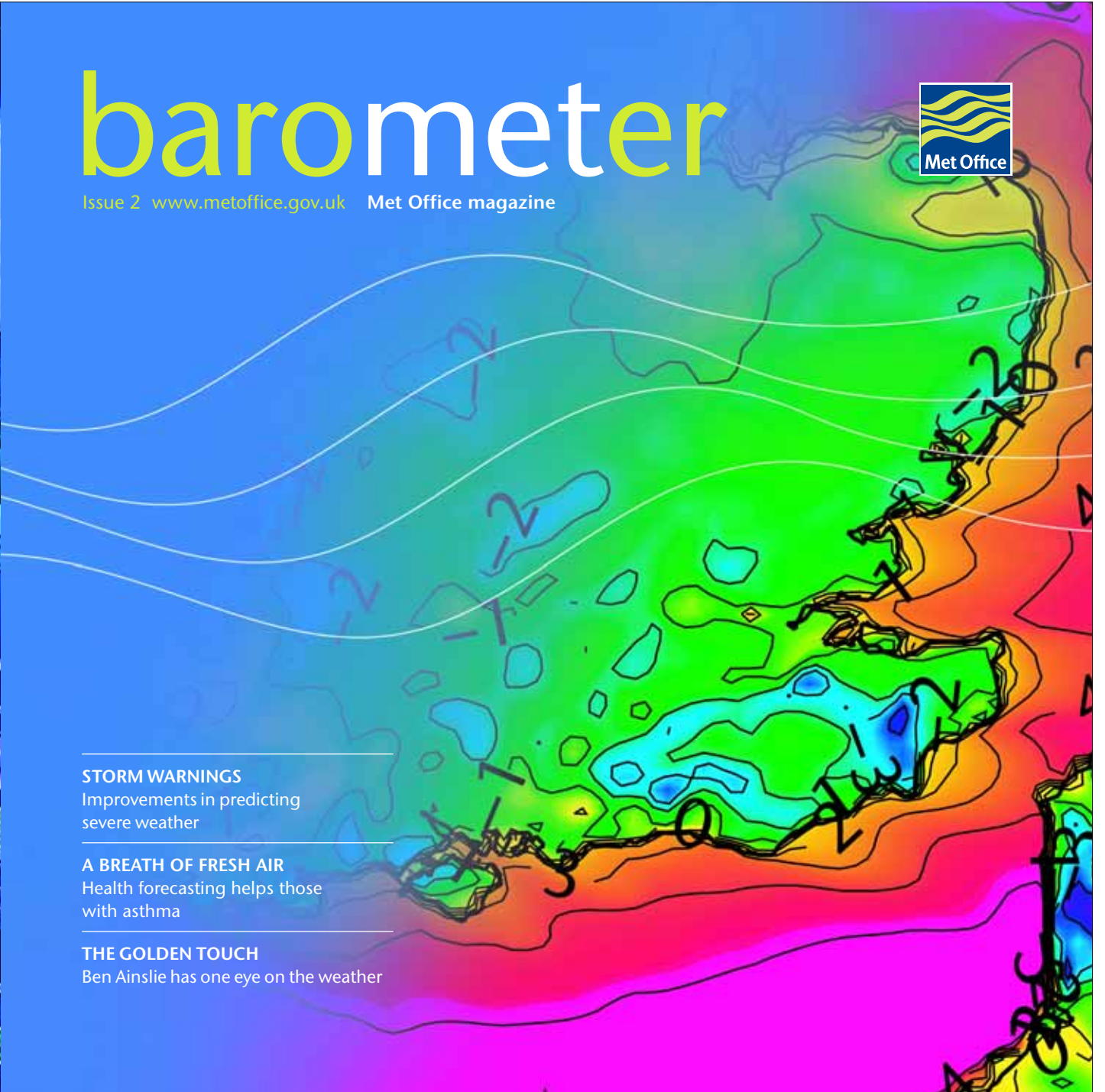
Improvements in predicting severe weather

A BREATH OF FRESH AIR

Health forecasting helps those with asthma

THE GOLDEN TOUCH

Ben Ainslie has one eye on the weather





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For queries about *Barometer* contact Sancha Tetlow Met Office, FitzRoy Road, Exeter, Devon, EX1 3PB, UK

For any queries about Met Office products or services, contact us at our Customer Centre (24 hrs):

Email: enquiries@metoffice.gov.uk

T: 0870 900 0100 F: 0870 900 5050

From outside the UK:

T: +44 (0)1392 885680 F: +44 (0)1392 885681

www.metoffice.gov.uk

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Science in all we do

Science underpins the wide-ranging forecasts issued from the Met Office, as Chief Scientist John Mitchell explains...



→ John Mitchell Chief Scientist

The Met Office is, perhaps unsurprisingly, best known for its weather forecasts, particularly through radio and television broadcasts. However, as we aim to show you in this magazine, we are involved in much more. In addition to providing a huge number of weather forecasts for a wide range of purposes around the globe, we also provide predictions for the oceans, the dispersion of pollution, climate change and the natural environment generally. Our research is not only aimed at improving existing products, but also providing services in new areas.

For example, March saw the launch of the National Centre for Ocean Forecasting. This is a Met Office collaboration with other oceanographic experts in the UK, aimed at providing as much information about the conditions within the oceans as we currently do for conditions on land and in the air (see page 3). Information about the ocean is required by a variety of organisations — including the Royal Navy and Maritime and Coastguard Agency — for a range of purposes, from ensuring safety at sea to planning marine and offshore operations.

The Met Office's Hadley Centre is the world's leading authority on the science of human-induced climate change. Earlier this year the Department for Environment, Food and Rural Affairs, Defra — which funds the majority of our climate work — asked us to host a major climate change conference at our Exeter headquarters. The aim of the symposium was to advance scientific understanding of the impact of climate change at different levels of stabilisation, and the ways to achieve such levels. One of the main themes was the extent to which it might be possible to identify an optimum response which avoided both dangerous climate impacts and unacceptable mitigation costs. The report will be used to inform the next meeting of G8 ministers in Gleneagles in June.

As you will see in this issue of *Barometer*, climate change is a fascinating and often difficult subject which is likely to affect us increasingly through this century. The issue of global warming — due to increased emissions of greenhouse gases into the atmosphere — is complicated by the associated increased emissions of small particles (aerosols). These particles reflect sunlight back to space in a similar way to clouds and cool our planet, a process referred to as 'global dimming'. This is discussed further on page 17 of this issue. The bottom line is that global dimming may have protected us from larger climate change to date, but the reduction of emissions may actually accelerate global warming.

All our predictions and forecasts are based upon numerical models, which are constantly being developed and improved by a comprehensive research

programme. The technology used encompasses everything from weather buoys and satellites to supercomputers. Advancing the development and use of technology is key to the improvement in accuracy and scope of the environmental predictions we provide. In the last 12 months our weather forecasting capabilities have been put to the test with events such as the flooding in Carlisle and Boscastle. The severe weather over Cumbria was well predicted, and the article on page 15 explains how, in the future, we will be able to produce the pinpoint predictions needed to anticipate events like the Boscastle flood. Crucially, our investment in new technology is already yielding encouraging results. A study comparing numerical forecasting models around the world found an 11% improvement in the accuracy of our forecasts following the introduction of our supercomputer. This contrasts with just 3% improvement across other modelling centres.

I hope that *Barometer* will help give you an insight into the science of the Met Office. A more detailed account of how science is contributing to improving and widening our capability is given in our *Environmental Prediction* brochure and on our website. Research on avoiding dangerous climate change can be found at www.stabilisation2005.com. Please feed back any comments you have to our Customer Centre on 0870 900 0100 or enquiries@metoffice.gov.uk

John F B Mitchell



The summer solstice – facts and myths

As the longest day of the year approaches, our thoughts turn to balmy evenings, summer holidays and weekends that seem to last forever. Throughout history, the summer solstice has been afforded deep meaning and is often shrouded in mystery.

The summer solstice is the longest day of the year and, in the Northern hemisphere, usually falls around 21 June, while in the southern hemisphere it is celebrated in December. The word 'solstice' comes from two Latin words: 'sol' meaning sun, and 'sistere', to stand still, referring to how the point on the horizon at which the sun rises, moves throughout the year. On the solstice this point stops and changes direction.

The movement of the sun has always fascinated people. The solstice has been celebrated for thousands of years by cultures all over the world and many myths have grown up around it. The oldest known ritual took place in Egypt, at the Temple of Amen-Ra in Karnak (pictured) at around 3700 BC.

Here, they built a temple with a sanctuary that became illuminated by a beam of light from the sun for two to three minutes on the day of the solstice. In ancient China, the solstice marks the festival of Li, the Chinese Goddess of light, with ceremonies celebrating the earth, the concept of the feminine and yin forces. The winter solstice celebrated the heavens, masculinity and yang forces.

The ancient Germanic, Slav and Celtic tribes in Europe celebrated Midsummer with bonfires. Couples would jump over the flames to bring luck.

In Sweden, villagers would dance around a decorated Midsummer tree, while women and girls would bathe in the local river. These were magical rituals, intended to bring rain for the crops.

Druids celebrated the solstice as the wedding of Heaven and Earth. It is thought that Stonehenge was probably built by the Druids between 3000 and 1500 BC, and the stones are aligned to the Midsummer sunrise.

Native Americans created many stone structures linked to the movement of the sun. One, set in a 20 acre natural amphitheatre in Vermont, features stone markers that denote solstices and equinoxes (the halfway points between the two solstices).

Fact file:

- > The seasons of the year are caused by the 23.5° tilt of the Earth's axis. The solstice is the day that the Earth's North Pole is tilted closest to the sun
- > The solstice is also called Midsummer — probably because it is roughly the middle of the growing season for crops
- > The summer solstice is also known as Alban Heflin, Alben Heruin, All-couples Day, Feast of Epona, Feast of St. John the Baptist, Feill-Sheathain, Gathering Day, Johannistag, Litha, Sonnwend, Thing-Tide, and Vestalia
- > The first (or only) full moon in June is called the Honey Moon. Tradition says that this is the best time to harvest honey from the hives
- > In ancient times, people picked plants and herbs at night on Midsummer, believing them to have miraculous healing powers





Magnetic north attracts PoleCats

It is bitterly cold, there are polar bears, and the sea ice they are walking on is constantly shifting, but, undeterred, three intrepid women set out on 22 April in a bid to become the first all-women team to finish The Polar Challenge. The challenge is a gruelling 320-mile race from the Canadian North West Territories to the Magnetic North Pole and no female team has ever completed it.

The Pink Lady PoleCats — meteorologist and writer Felicity Aston, Sam Eve and Tori James from BSES Expeditions — endured

temperatures as low as -40°C during their adventure. Having already taken part in expeditions to areas including Greenland and Antarctica, they were keen to test their skills to the limit.

Set up only two years ago, the Polar Challenge has established itself as one of the toughest adventure races in the world. Find out how the PoleCats got on in the next issue of Barometer.

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



Forecasting for safer seas

Oceans cover about 70% of the Earth's surface and around 60% of the world's population lives within 200 km of the coast. For those who work at sea or live near the coast, forecasts of ocean conditions can be just as important as forecasts of the weather.

To address this, the National Centre for Ocean Forecasting (NCOF) was officially launched at the Met Office in Exeter earlier this year. As a strategic partnership between the Met Office and the Proudman Oceanographic Laboratory, Plymouth Marine Laboratory, Southampton Oceanography Centre and the Environmental Systems Science Centre at Reading, NCOF will co-ordinate the nation's ocean forecasting activities, and establish them as part of the national infrastructure. The plan is to provide as much information on the conditions in the oceans as is currently available about the weather.

Ocean information is required by many different organisations for various purposes: for disaster mitigation; ensuring safety at sea; marine and offshore operations; sustainable development and exploitation of the marine environment. Making ocean forecast information available to them is vital to ensure their needs are met.

For more details, visit the NCOF website at www.metoffice.gov.uk/research/ncof/index

Greener cities

Are we green enough? This is a question we will all be increasingly asking ourselves as the world's population gets bigger and bigger.

By 2030, more than 60% of us will live in urban areas, according to the United Nations. From poverty and unemployment, to crime and drug addiction, such rapid urbanisation will bring profound challenges.

Cities are prolific users of natural resources and generators of waste. Urban areas, predominantly in the developed world, are currently responsible for most of the greenhouse gas emissions that are contributing to climate change. Meanwhile, the expanding mega-cities of the developing world face ever-growing health problems caused by poor air quality and sanitation.

World Environment Day on 5 June 2005 is an annual event organised by the United Nations to draw attention to these issues. This year's theme is Green Cities and people around the world are being encouraged to be more environmentally-friendly by planting trees, recycling more and cleaning-up their localities.

For more details, visit www.wed2005.org



Dry start to the year



A man walking across Pitsford Reservoir, Northants which had dried up during the 1976 drought

By the summer of 1976 the weather had been so dry that British water supplies reached critically low levels and the Government had to introduce the Drought Act to monitor water usage. Already, this year, the winter period is being compared to that of 1975/76. Records going back to 1914 show that the period November 2004 to March 2005 — which had an average rainfall of 283 mm — was the driest in England and Wales since the same period in 1975/76.

The first half of February this year was mild in the UK, with the wind from a west or south-westerly direction. However, winter returned with a vengeance after the 18th as the wind turned to a north or easterly direction,

bringing sub-zero temperatures and snow to many areas. The last day of the month ushered in just enough rainfall to change the ranking of the winter for England and Wales to the driest since 1996/97 (rather than since 1991/92). However, the dry trend did not continue into April which had around or just slightly above, rainfall average.

The winter lion was still roaring as Spring officially started in March. A number of Met Office severe weather warnings were issued as heavy snow showers moved across the country. Snow drifts of up to 30 cm blanketed the Downs in south-east England, resulting in transport disruption and cheers from children in Kent and Sussex as some of their schools were

temporarily closed. As a result of almost two weeks of intermittent snow showers Boltshope Park in Durham reported 40 cm of snow lying on the 3rd, with much of the snow staying on the ground until 14th. However, despite the chilly start to the month mean temperatures in March actually ended up being well above average.

Elsewhere residents of the world faced everything from heatwaves to torrential rain. Albuquerque in north-western New Mexico was drenched by 15 mm of rain over 14–15 March, despite the average total for March being just 12 mm. At the same time, parts of the Western Cape in South Africa sweltered in a heatwave, with temperatures climbing to more than

38°C — around 10 degrees higher than the average March maximum. Meanwhile, Sweden was in the grip of a deep freeze. Residents of Kvikkjok pulled on their thermals as the temperature fell to minus 34.5°C ; much colder than the average March minimum of a comparatively 'warm' minus 13°C .

On 20 April, temperatures soared to 35.8°C in Ashkhabad in Turkmenistan, above the average April maximum of 22°C . Heavy rains fell across other parts of the globe. In Pendra, eastern India, a line of thunderstorms resulted in 27 mm of rain in nine hours on 20 April; most falling in less than six hours. The average April rainfall at Pendra is 25 mm. On the same day, an intense thundery trough swept from the south across Bolivia bringing a deluge at Yacuiba. A total of 126 mm fell in 24 hours, compared with an April average of 114 mm. Meanwhile, Iceland enjoyed some unseasonably warm weather. Temperatures at Akureyri rose to 13.1°C — considerably higher than the average maximum of 4°C .

The latest predictions for the coming summer favour warmer-than-average temperatures for much of northern Europe, from Britain to north-west Russia. However, this does not mean we can look forward to paddling pools and barbecues every day in Britain. Remember, whilst Summer 2004 was a full degree warmer than average, it was very wet, especially in August. Don't consign your brollies to the cupboard just yet!



Formula 1 forecast

Fifty years ago, Stirling Moss became the first British racing driver to win his home Grand Prix, narrowly beating his Mercedes-Benz team mate, Juan Manuel Fangio.

With Moss in pole position, it was the legendary Fangio who made the better start at the Aintree circuit. Varying weather meant that track conditions were inconsistent but Moss managed to nudge past Fangio on the third lap, only to see the Argentine gain the lead for a second time on the 18th. In front once more on lap 26, Moss and his teammate ran nose to tail for the remainder of the race, with Moss crossing the finish line just 0.2 seconds ahead.

Today, despite many advances in Formula 1 technology, the weather can play havoc with an event. Racing for more than 90 minutes and in a precise 1 km area, Formula 1 needs more than a typical weather forecast. Drivers, engineers and technicians need to know what temperature, wind speed and direction to expect; whether it will rain and at what time. Wet running in particular, can seriously affect tyre grip and the cars' performance.

The Met Office supports all Formula 1 Grand Prix events by providing text forecasts. As the event approaches, crucial weather information is provided for Practice Day, Qualifying and The Race itself. Today, forecasting methods are almost as hi-tech as the cars themselves, but with margins still as close as the 1955 Grand Prix, accurate weather advice can give race teams the winning advantage.



The golden touch

With another gold medal at the 2004 Olympics to add to his collection, Ben Ainslie is considered one of the UK's greatest dinghy sailors. His awareness of weather conditions helps to keep him at the top of his sport.

There are few sports more demanding than competitive dinghy racing. It requires exceptional agility, stamina, skill, and a very tactical mind. Races can be won or lost before the boat is even on the water, and much of this is down to the weather and how the boat is set up.

In the 2004 Olympics, Ben sailed to victory in a class of boat called a Finn, which is a 4.5 metre, single-handed racing dinghy. "Setting up the Finn is really important," Ben explains. "For example, you have to choose the right sail for the conditions: heavy-weight for strong winds and lighter for soft winds. In fact, the whole set up of the rig changes according to the wind strength."

Although the boats can be fine-tuned to gain maximum performance in

certain weather conditions, Olympic regulations don't allow competitors to receive weather forecasts while on the water, so each competitor needs to gather as much information as possible before they set sail.

"Our team had professional weather forecasters helping us plan before each day's sailing," Ben says, "but once you're on the water, you have to respond quickly to changes in the weather and try to turn it to your advantage."

And the weather is always ready with a few surprises. Ben remembers a dramatic change in conditions during the 1996 Olympics in Atlanta that turned a relatively calm day into the kind that has most people running for cover.

"When we started racing, the wind was about 10 knots, but intense heat had accumulated over the land which caused thunderstorms, bringing torrential rain and pushing the wind suddenly up to 30-40 knots. In other words, a gentle breeze became a gale. At the same time, the temperature fell by around 25 degrees."

Whereas many competitors might have been caught off-guard by such a sudden change, Ben used it to his advantage. Having learnt to sail off the coast off Cornwall, Ben was comfortable in the heavier conditions, so he made up a lot of ground in that particular race and went on to win his first Olympic medal. Experiences like that — and a general respect for the water — have ensured Ben is careful to check weather forecasts before setting sail, even when he doesn't have the backup of professional forecasters.

"The internet is a great tool for finding weather forecasts and I often use it when I am travelling abroad to find out about the day's conditions."

Ben's successes over the last nine years include two Olympic gold medals and many European and World Championship titles. He has also been awarded an MBE, twice named ISAF (International Sailing Federation) World Sailor of the Year and four times British Sailor of the Year. With so many achievements to his name, what challenges are left?

"There is always something new in sailing. I'm currently training for the 2007 America's Cup, where I'll be sailing 80 ft yachts as part of a crew of 17. It's very different from sailing a single-handed dinghy; all the manoeuvres happen much slower but on a much larger scale. It should be an interesting challenge."

If Ben can adapt to a different style of sailing in the same way that he adapts to the changing weather, there's sure to be many more podium places on the horizon.

● marinecall

Safety at sea

Marinecall makes it easy for people to access Met Office weather forecasts for inshore and offshore coastal areas in the UK. Its aim is to keep people safe whenever they are working or enjoying leisure time in or around the sea.

Marinecall offers a range of services to provide accurate forecasts in the most convenient way, whether by phone, fax, email, direct to a mobile via WAP or on the internet. It also offers advice on how to use forecasting information such as satellite images and rainfall radars.

Here are just a few of the services provided by Marinecall:

Fax forecasts: use your fax machine to receive updates on the specific area you are interested in

Telephone forecasts: access an extensive range of services at the touch of a button, including 5-day forecasts and coastal location forecasts

Talk to a forecaster: talk directly to a Met Office forecaster, 24 hours a day

MetWeb: a comprehensive range of weather forecasting services online

Marinecall SMS: get today's weather report for your chosen coastal area, direct to your phone via text message

Marinecall email: a free weekly email overview of coastal waters for the coming weekend

Satellite images: information on how to access and use images from weather satellites

These services and many more are described in detail in the **Marinecall Marine Weather Services Handbook 2005**, which also includes contact numbers and other useful information to help you stay safe at sea. For your free copy, call Marinecall customer services on 0871 200 3985 or log on to www.metoffice.gov.uk

Keeping track of events

Stewart Wortley has to react quickly to emergency events; be it a storm tide, a nuclear accident or an erupting volcano.

Image from TV drama Supervolcano: BBC/Impossible Films

→ Our people

www.metoffice.gov.uk



08

“Within 20 minutes of an incident, we can provide a dispersion forecast and an Area At Risk map for the emergency services.”



Stewart Wortley works in the Operations Centre at the Met Office in Exeter as manager of the Public Met. Service. His career began at 16, when he left school and joined the merchant navy as a deck officer. After 15 years he had worked his way up through the ranks to Captain.

By 1997, he had tired of life at sea and joined the Met Office to work for the MetRoute shipping service. After training as a forecaster, he joined the Operations Centre and in 2003 began managing the Public Met. Service.

One of his major responsibilities is running EMARC, the Environment Monitoring and Response Centre. The EMARC is responsible for a vast range of special services, such as monitoring volcanic eruptions and floods and providing advice on marine and air pollution.

One of the main tools used by EMARC is the Met Office's atmospheric dispersion model, which tracks the movement of nuclear fallout, volcanic ash, diseases and even locusts.

Stewart explains: “The dispersion model was developed in the aftermath of the Chernobyl accident — when the nuclear reactor exploded — and is now used to provide many other services. For example, it helps us to track volcanic ash following an eruption, which is especially important for aviation, as the BBC drama Supervolcano (broadcast in March) showed in graphic detail.”

Volcano danger

If a plane flies through thick volcanic ash, the jet engines can clog up and stop, creating a real danger that the plane could fall from the sky. Timely alerts on the movement of the ash help pilots avoid the plumes which rise high into the atmosphere following an eruption.

EMARC also monitors for atomic bomb tests and would track fallout in the event of a nuclear accident. “Our dispersion models are even used to track the spread of diseases such as foot and mouth,” says Stewart. “We can run the models backwards to help identify the source of the disease.”

The dispersion models are also used in the event of chemical spillages or accidents.

“Within 20 minutes of an incident, we can provide a dispersion forecast and an Area At Risk map for the emergency services. This helps them to position emergency crews and see where people need to be evacuated from.

“Our models were used in the Gulf to predict the movement of smoke from oil fires during the invasion of Iraq. They can also be used to predict sand storms and even the movement of locusts.”

Protecting life and property

Stewart also oversees the International Forecast Unit and the National Severe Weather Warning Service. This is one of the Met Office's most important responsibilities, providing information freely to the public to help protect life and property. There is always a team of people watching the weather in case they need to raise the alert. If a severe weather incident does occur, then additional help may be needed, and more often than not this will be Stewart.

“Sometimes it is necessary to bring in an extra person. Since I am a trained forecaster, it is likely to be me. I'm there most times during the day and I can easily step in and help out.

“During a storm, for example, you might have a huge number of phone calls to deal with. If there is an extreme incident we might start calling the emergency services and local authorities, among others, to warn them of what is coming. On one occasion, the Chief Forecaster in the Operations Centre even phoned the Danish meteorological office to warn that a storm was coming their way.

“We can also react quickly to major incidents around the world. For example, I was on shift on 27 December, the day after the tsunami struck South East Asia. That day we started issuing special forecasts for the crisis region to aid the relief effort. As the days unfolded and the news became filled with images of the devastation, I was glad that I was involved in setting up the forecasts for the relief effort, but felt at a loss as to how else I could help. Having been to all the areas involved during my time at sea, the effect that this was having on the local people was very real for me.”

Stewart is also a father of two children, which brings its own forecasting duties. “The school asks me for a special forecast for sports day,” he says. “Last year I was able to warn them to postpone it, and it did rain. The alternative date I suggested was a lovely sunny day. That was lucky — I was glad I got that one right or I might never have lived it down.”



Storm warning

As technology gets better, so will the ability to warn of severe and extremely localised events.

The Cornish village of Boscastle is set in a steep gully where two valleys meet, formed by the rivers Valency and Jordan. A third river, the Paradise, also flows through the area.

On 16 August 2004, a series of thunderstorms developed in a narrow line near the North coast of Cornwall, causing vast quantities of water to thunder down the valleys and through the village, demolishing at least one building and damaging many more. Sixty-foot trees were hurled down the valley like matchsticks, around 70 cars and vans were swept out to sea and police said it was a miracle no one was killed.

Parish councillor Philippa Arthan talks about what happened that afternoon. The morning had been fine, and she was outside, decorating.

"I had been stripping down the paintwork on an outside window. I noticed it started raining at about 1pm because I was just about to start putting an undercoat on, but at that point I still really thought I could get the job finished that day."

She says even those actually in the village didn't really know the extent of what was happening.

"There were torrential storms and thunder during the afternoon. At around 4.30pm my neighbour came round and said we should walk down the village for a bit of an adventure because the water was rising fast. It wasn't until we got to the hairpin bend at the bottom of the village that we realised the harbour area had become a dirty brown lake."

Better awareness

If they had been aware of the extent of what was taking place, would it have made a difference? Philippa thinks so, but, she admits, at the time people would probably have still been unwilling to evacuate their homes.

"Now, of course, they would understand, after what has happened," she says. "Better awareness of what could happen would certainly help people cope in future. The shopkeepers could have got their goods inside, and people could have used sandbags and boards to try to better protect their homes and shops."

"It wasn't until we got to the hairpin bend at the bottom of the village that we realised the harbour area had become a dirty brown lake."

Tim Wood was the Environment Agency duty officer at the time of the Boscastle flood. By the time the first alarm was received from the rain gauges in the area local flooding was already occurring. Although the storms had been forecast, the actual rainfall was extremely localised, with some gauges 10 km away from Boscastle recording less than 10 mm. Once the river levels started to flood the village local residents alerted each other and visitors to the danger.

"By about 5pm we had received reports about flooding in Boscastle, but nothing horrendous. Our office was very busy and river levels were rising everywhere in North Cornwall. We began to get reports of cars being swept away at Boscastle but the first we knew of the scale of the event was the 6pm news which came on the TV in the communications room."

"You can imagine the shock of seeing those pictures. I couldn't reconcile it. As far as we were aware, only 60 mm of rain had fallen and it wouldn't create a flood like that. I was in a state of shock for several days. It was an appalling

The Boscastle flood

- Torrential rainfall was recorded at several gauges: 200 mm at Otterham in 24 hours; 185 mm at Lesnewth in 24 hours. However, most of the rain actually fell in a five-hour period. Peak intensities were in excess of 300 mm/hr (5 mm per minute)
- The rain was very localised: four of the nearest 10 gauges recorded less than 3 mm in total
- Two million tonnes of water flowed through Boscastle that day. Water speed was in excess of 4 m/sec (10 mph) — more than enough to cause structural damage



situation. We had no idea of the extent of that flood. It wasn't until two days later that we found out that up to 200 mm of rain had fallen in 24 hours."

During and after the flooding in Boscastle the Met Office and Environment Agency worked closely with the police, the emergency services and search and rescue to help them co-ordinate the response and recovery operations.

New supercomputer

Such an event is a challenge to the Met Office's operational forecasting capability, because of the very rapid onset and small geographical scale. To solve this more powerful computers with higher resolution models* are needed, computers such as the new NEC SX-8 which came online at the Met Office Exeter headquarters this spring.

The supercomputer was put into action in two stages. The Office now has twelve times more processing power than two years ago.

We have invested, and will continue to invest, in new technology and, as

technology improves further, so will the forecasts.

Tim Wood welcomes the upgrade:

"We're really happy to work closely with the Met Office to improve our understanding of such events. Partnership is the only way we will move forward. To help in a situation such as Boscastle, you need to have accurate weather radar and total confidence in the forecast data. Don't forget that with a flood like that, you really need to issue a warning at least two hours in advance and at that point it hasn't even rained. To give that order, requires exceptional confidence in the system."

* See Peter Clark's Science Focus feature on P15.

Seeing close up

Anyone who has ever used a digital camera will know that the higher the resolution, the better the picture. Even if the terminology is not familiar, you will recognise the end result. Low resolution means there is not enough digital information packed into the image. If you try to enlarge the image you will see the lack of detail. In fact, the closer you look, the less you see. With a higher resolution, you have lots of information packed into a small space, so you can see close, precise detail.

Something similar is happening in the computer models used by weather forecasters. Each grid in the model is like a pixel in a digital photograph. A more powerful computer allows users to pick up more detail in the computer models, so they can see what is happening on a local scale rather than just a regional scale.



1964 satellite image



2004 satellite image



A breath of fresh air

A new health forecasting service could be music to the ears of people with asthma.

People with respiratory conditions often find the weather makes a huge difference to their condition. One day they might have few, if any, problems. The next, they might be struggling to catch their breath just walking down the street.

The changing seasons can also have a dramatic impact, with many of those with respiratory problems finding their condition gets much worse on hot summer or cold winter days. Then there's spring with its pollen, and even autumn to worry about as a wide variety of mould spores are released into the atmosphere. Knowing in advance what the weather has in store is vital and could even make the difference between life and death.

Agnes Gallagher, 61, of Liverpool, has a chronic respiratory condition. Last Christmas she was able to spend it at home, instead of the hospital, as has happened in the past, because of a new type of weather warning from the Met Office. Agnes lives in an area covered by Central Liverpool Primary Care Trust, and her District Nurse, Maureen MacDonald, received a health forecast from the Met Office, warning that the weather conditions which can exacerbate Agnes' condition were expected.

As soon as she saw it Maureen knew that Agnes was at risk and, instead of simply phoning, went to her home and quickly realised the weather was already having an effect on Agnes.

She explains: "The forecast showed an above average risk of more bad weather and she might well have ended up in hospital. We were able to get to her quickly and prevent her condition deteriorating any further by giving her the antibiotics needed."

Agnes says: "I was on the verge of going along to the hospital before the nurse came out to see me but instead I was able to stay at home. Nobody wants to go to hospital if they can help it, so I think this is a marvellous scheme."

Early warnings

A health forecasting service that could help people with various conditions control their symptoms is currently being developed. Although still in the early stages it is already enabling health authorities across the country to save the lives of people with a range of breathing difficulties.

Initially the health forecasting service has focused on chronic obstructive pulmonary disease (COPD) — a serious condition affecting more than 1.75 million people in the UK; people like Agnes. By warning Primary Care Trusts when people in their region were at risk, they have been able to deliver effective preventative care.

The health forecasting team — made up of meteorologists, health workers and a medical doctor — hopes to develop an asthma service over the next few years.

Caroline Moye, of Asthma UK (formerly The National Asthma

Campaign), says: "The seasons certainly affect the 5.2 million people in the UK living with asthma every day of their lives. We see how the concerns of people calling our Adviceline change to match them."

Caroline adds that simple, everyday things like spring-cleaning and autumn bonfires can cause asthma symptoms to get worse, and this is where the Met Office comes in.

Mark Gibbs, from the Met Office, says: "As someone with asthma myself, I know that the weather has a dramatic impact on symptoms. There are a lot of factors that affect asthma and everyone is different. For me, pollen is the main problem. We do know, however, that one of the biggest problems is summer thunderstorms. When these happen, even people who don't normally get asthma can show severe symptoms."

Thunderstorm effect

On one day during a thunderstorm in the summer of 1994, more than 1,000 people in London went to hospital accident and emergency departments suffering severe asthma attacks.

"Normally they would expect a couple of hundred," Mark says. "There was another incident a few years later where Addenbrookes hospital in Cambridge was overwhelmed with people with asthma during a thunderstorm. There was one fatality and the hospital ran out of drugs."

Running out of breath

Alison Bottomley, 52, is a regular runner who has completed dozens of half marathons and three London marathons, despite having asthma. She is badly affected by the weather conditions, and some days she simply cannot train.

"When I go from sudden heat to sudden cold, and the other way around, is when I have the most problems," says Alison, of Tollerton, Nottinghamshire. "The wind is also a problem when I'm out running. It comes whipping across the fields and stops me dead in my tracks."

She is also badly affected by thunderstorms. "I always know when one is coming," she says, "because I start to feel the tightness across my chest. I also suffer on hot days with the air pollution. Then in spring there is the dreaded oil seed rape fields. Sometimes I just can't go out of the house for days on end. I'm not able to train — I'm not even able to walk, never mind run."

"If I could know when things are going to be bad, I could plan my training around it. For example, knowing whether to go out for a run in the morning or in the evening would make a huge difference to my life."

Nobody really knows why thunderstorms have such an impact but, according to Asthma UK, several studies have shown there is a direct link. This could be due to the release of pollen into the air, the humidity, or perhaps both combined. The charity warns that people with asthma need to be aware of a range of weather-related factors that could influence their symptoms.

The Met Office health forecasting service could make a huge difference to people living with asthma.

Asthma UK's Chief Medical Adviser, Professor Martyn Partridge, says: "A sudden change in temperature, cold air, windy days, poor air quality and hot, humid days are all known triggers for asthma. More than 80% of people with asthma find air pollution makes their asthma symptoms worse. This is of particular concern during the summer months when ground-level ozone increases."

Asthma and the Four Seasons

The composer Vivaldi had asthma all his life and it is believed his most famous composition, *The Four Seasons*, reflects how his symptoms were affected by the changing weather.

Listen to the Summer concerto again, and see if you can hear those drowsy, heavy chords. Do they become constrained, showing how the summer storms are making his breathing difficult? In the Winter concerto, do those painful notes mean that his chest is tight because of the cold?

For more information on how to control your asthma go to: www.asthma.org.uk. Or call the Asthma UK Adviceline on: 08457 01 02 03

Fact file: Asthma

- > Asthma affects airways that carry air in and out of the lungs, making them sensitive and inflamed. When an attack is triggered, the airways tighten, making breathing difficult
- > According to Asthma UK, there are 5.2 million people in the UK currently receiving treatment for asthma
- > In the UK, 1,400 people die from asthma each year — an average of one person every seven hours
- > Asthma UK estimates that 75% of hospital admissions for asthma are avoidable, and as many as 90% of deaths from asthma are preventable
- > Respiratory disease is the most common illness responsible for an emergency admission to hospital. Asthma costs the NHS £889 million per year on average
- > Over 12.7 million working days are lost to asthma each year
- > World Asthma Day is always the first Tuesday in May





Back on court

Visit any park in Britain next month and you'll see people hitting a ball with a racket. Tennis fever — or, for some, Henmania — grips the nation in June when the world-famous Wimbledon Championships take place.

→ Feature

www.metoffice.gov.uk



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The Wimbledon Championships are played on grass courts at The All England Lawn Tennis & Croquet Club in London, and every year the weather affects them in one way or another.

The official statistics book even has a year-by-year summary of the weather during the tournament, dating to 1919. Since then, Wimbledon fortnight has been extended 15 times because of rain. Most recently, in 2001, Goran Ivanisevic and Pat Rafter had to play their final on a Monday. Only six tournaments have been unaffected by rain and, according to the statistics, rain has completely washed out 30 days of action since 1877. The All England Club has a wet weather policy, which applies if the weather affects play and it needs to refund ticket money. The Club announced last year that a retractable roof will eventually be put over Centre Court but that is another four years away, so this year's championship, from 20 June to 3 July could still be affected by the weather.

Less bounce

Grass surfaces are the most sensitive to the weather, with a fine drizzle making the court slippery and dangerous, and even an overcast or humid day leaving the grass slightly damp. Playing on wet grass also damages the surface and means the ball has less bounce, making it harder work for the players. Temperature can affect the balls and rackets. Balls expand and shrink in the heat, which makes them react differently. Racket strings made from natural gut (which many professional players use) are particularly sensitive to the weather. The heat can also affect the players themselves. There are international guidelines about the maximum temperature allowed in a court. Players can use the wind to their advantage; hitting harder when facing the wind and with more topspin and shorter backswings on ground-strokes when the wind is at their back.

Wimbledon history

It is more than 100 years since 200 spectators paid a shilling each to watch Spencer Gore win the first Lawn Tennis Championship at Wimbledon. A Gentlemen's Singles event only, the champion received a Silver Challenge Cup and the Gold Prize of twelve guineas. Just 22 men entered. The Ladies' Singles competition began in 1884, with Miss Maud Watson triumphant out of the 13 entrants.

The first shorts weren't seen on Centre Court until 1933 — worn by Englishman Bunny Austin.

During World War II a bomb ripped through Centre Court and 1,200 seats were destroyed. Fortunately no-one was sitting in them at the time.

For more details about Wimbledon, visit www.wimbledon.org

Wimbledon facts:

- > Most Men's Singles titles: William Renshaw, seven — 1881–86, 1889 and Pete Sampras, seven — 1993–95, 1997–2000
- > Most Women's Singles titles: Martina Navratilova, nine — 1978, 1979, 1982–87, 1990
- > Youngest Men's Singles champion: Boris Becker, 17 years (1985)
- > Youngest Women's Singles champion: Martina Hingis, 15 years (1996)
- > Youngest Men's Singles seed: Bjorn Borg, 17 years, 19 days (no. 6 in 1973)
- > Youngest Women's Singles seed: Jennifer Capriati, 14 years, 89 days (no. 12 in 1990)
- > In 1980, Sweden's Bjorn Borg became the first player to win the Men's Singles title five times in succession since William Renshaw in the late 1880s
- > Every summer 24 tonnes of strawberries are eaten at the Championships
- > 40,000 tennis balls are used each year

Sport and weather facts

- A cricket captain will change his tactics and team selection according to the weather forecast. Overcast conditions might call for an extra seam bowler. Sunny weather could make the pitch dry and cracked, so he might want an extra spin bowler. Should he bat or bowl first? When should he declare? It all depends on the weather
- Weather conditions are vital to horse racing. The rain and sun affect the 'going' — the condition of the track — and can decide which horse will win
- Mountains can be inhospitable and dangerous places for the ill prepared. Weather conditions can vary dramatically from one hour to the next and one hill to the next, so climbers,

orienteers and mountain bikers must keep an eye on the weather forecasts

- In athletics, if you break a world record but you have too much wind assistance, it does not count. Wind of more than two metres a second in the 100 m, 200 m, 110 m hurdles, long jump and triple jump nullifies a record time
- Sports such as sailing, windsurfing, surfing, mountaineering and flying are all dependant on different types of weather. In many of these sports it is not just a matter of winning and losing, but a matter of life and death
- Formula 1 racing teams fine tune their cars to suit the weather. Different air and track surface temperatures call for different tyres, which have a critical affect on performance





Predicting local weather with numerical models

The weather can vary greatly over very small distances.

Peter Clark, Mesoscale Modelling Manager at the Joint Centre for Mesoscale Meteorology, sees the weather in small scale.

Driving along through a patch of fog, you may suddenly emerge into bright sunshine, perhaps with a stunning view of fog in the valley below. Another day you might be soaked by a thunderstorm that your friend a few miles away is only aware of through the distant rumble of thunder. Sometimes, the rain from storms may be so heavy that flooding can happen very quickly and very dangerously. We were reminded of this on 16 August 2004, when the Cornish village of Boscastle was severely damaged. This presents a particular challenge to forecasting.

Numerical models and resolution

Our computer model simulates the behaviour of the atmosphere by solving equations representing physical laws. Computers are nowhere near powerful enough to simulate every detail of every detail of every gust of wind, so instead, we have to make approximations by treating average behaviour in some way. We express the resolution of our models in terms of the spacing between the grid points, though models only accurately resolve features larger than about five grid lengths. Currently, the finest resolution weather forecast models we run operationally have a grid length of about 12 km, so features smaller than around 60 km are not well resolved.

Current models are very good for predicting general developments of the weather, but averaging brings two problems. Following an initial step to average the processes we estimate the effect these have on the atmospheric

flow. Unfortunately, we do not know how (or even if it is possible) to do this perfectly, so errors creep into the forecast. Secondly, even if we produce the perfect, averaged model, it can only tell us a limited amount about where problems will occur. The output from our models can, at best, tell us that a region — such as East Anglia — will tend to have fog patches in the evening, or that thunderstorms will break out in the Midlands this afternoon. To improve on this we have to apply other techniques, making use of our experience to estimate which particular areas will be most affected.

Major jump in resolution

Thunderstorms are 'convective' clouds, in which warm air rises vertically into colder air, driven by the heat released as cloud forms. Major thunderstorms may be 5–10 km across. The size of these storms is a big problem for our 12 km grid length model when we try to average as, ideally, we would like to average over several clouds. Our new SX-8 supercomputer gives us the power to avoid the averaging problem by running models which represent the flow in large convective storms explicitly. We shall shortly be operationally launching a model covering the UK with a 4 km grid length. This brings major advantages; storms in the model can respond realistically to features such as hills and valleys, coasts etc. Other aspects of a forecast — in particular, fog and surface icing — are also treated much more accurately as surface features are much better resolved. Four km is not ideal, as

only the very largest storms are resolved reasonably well. We are already experimenting with models with a 1 km grid length, though these are too expensive to run operationally at present. **Figure 1** shows what our new 4 km model, and a 1 km model, would have produced for the Boscastle flood, compared with the operational 12 km model at the time. The 4 km model clearly highlights a major risk, but is not good enough to zoom in on the precise location. The 1 km model forecasts the location better.

What is the chance of a thunderstorm?

We are currently developing systems which forecast the development of individual major thunderstorms with perhaps 2–3 hours notice. Beyond this time, however, there are always likely to be errors in the precise location of

storms. The model can still tell us that storms will occur, and the risk of heavy precipitation from them. This is very useful information, especially if one area is more likely to be affected than others. We are therefore developing techniques to present forecasts which extract the most reliable information about location, while using more uncertain information to give guidance on the probability of severe events (**Figure 2**).

A new era in weather prediction

Higher model resolution is useful for many things. For example, **Figure 3** shows predictions of near-surface air temperature from a 4 km model compared with our current 12 km model. Much more detail is apparent which will be very important for providing guidance on potentially dangerous road conditions.

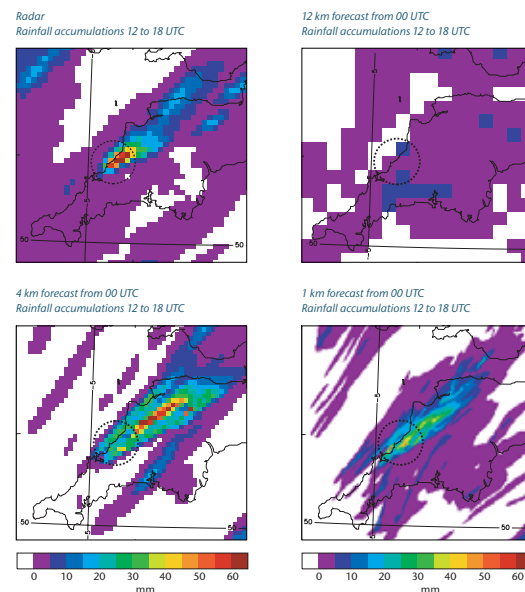


Figure 1: Examples of what our new 4 km model, and a 1 km model, would have produced for the Boscastle flood, compared with the operational 12 km model at the time



Science profile



→ Richard Betts
Manager of Ecosystems and
Climate Impacts Group

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

Richard Betts likes to think beyond the narrow boundaries of scientific and academic disciplines, because he knows that when you are studying climate change, you have to see the bigger picture. "It's not enough just to study the climate and look at atmospheric causes. You have to bring it back to people and life," he says.

Richard joined the Met Office's Hadley Centre for Climate Prediction and Research in 1992. He started modelling

land-surface processes for his PhD at Reading University, and over the years his work has evolved into modelling vegetation systems and their impact on the climate.

Earth like a living being

"When I first started, this whole idea was a bit esoteric. People thought it was interesting but not really important. However, about five years ago, people began to realise that it is one of the most important parts of the climate system. It is now central to the whole thrust of Hadley Centre research."

Richard studied physics at Bristol University. He then took a Masters degree in meteorology and applied climatology at Birmingham University, which included a thesis on measuring and modelling evaporation.

"That's what first got me interested in the land-surface aspect of climatology and meteorology, and it significantly influenced my world view. I became very interested in the Gaia hypothesis put forward by the scientist James Lovelock," he says.

This theory considers planet Earth as like a self-regulating living being. "It was very controversial in its day but is now widely regarded as a useful metaphor," says Richard. "It is important in climatology

and meteorology because it sees the world as an integrated system."

Significant impact

Richard's work with the Ecosystems and Climate Impacts Group is helping scientists around the world understand more about how what happens on the surface of the planet — such as the growth of vegetation — can have a significant impact on weather and climate.

"Rainforests can make it rain and help to maintain their own climate. Thick forests keep it cooler and wetter and recycle water. In the Amazon basin there is a significant recycling of water across the South American continent. To understand what is happening, we need to look at the whole effects of global warming and take a holistic view."

The group has also made some important and surprising observations, which the world community will need to take into account when planning how to deal with climate change. For example, it has demonstrated that planting forests to slow global climate change isn't always a good idea.

Planting a forest would help take up carbon, but this isn't the whole story. If, for example, you plant a forest in the far north — such as Canada or Siberia — then this also affects the reflection of

sunlight off snow. By making the landscape darker, you help to keep the climate warmer. On the other hand, tropical forests have an additional cooling effect through evaporation.

"One of the implications of Lovelock's thinking is that it encourages you to think not only about your own specialism, but other areas of science as well," he says. "I am trained as a physicist but I am doing work now which is closely related to the work of biologists."

"There is still a lot to do before we can get a more complete picture, but we need to understand more about the changes we are making to the Earth's ecosystem. What you need is a full world view. We want to make sure that all the scientific aspects are taken into account."

Early bluebells?

Richard says many plant species seem to be developing earlier in the year — and bluebells are among the most noticeable in the British countryside.

"These observations indicate that spring is coming earlier, which is consistent with a warming of the climate," he says.

Many migrating bird species are also arriving about a week earlier than they did about 20 to 30 years ago.

We are at the start of a new era in numerical weather prediction as models which forecast individual thunderstorms and other severe local weather are becoming a useful reality. We should treat their first, faltering, steps with caution but they will undoubtedly get better as the science and computer power improves.

For more information about our ongoing NWP work visit www.metoffice.gov.uk/research/nwp/publications/nwp_gazette/index.html

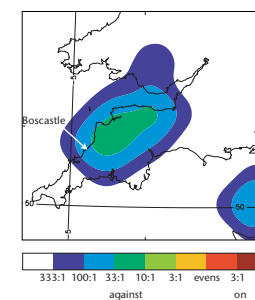


Figure 2: The forecast odds of receiving more than 50 mm rain over a 4x4 km area between 12 and 18 UTC 16 August 2004, from 03 UTC forecast

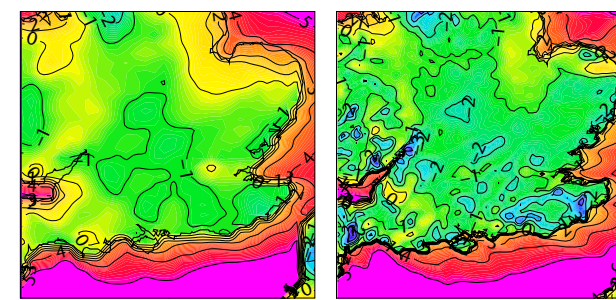


Figure 3: Predicted near-surface air temperature from the 12 km model (left) and 4 km (right) showing considerably more detail about frost areas in the 4 km model



A dim future?

Global warming, the greenhouse effect, climate change — all phrases we have become accustomed to hearing on the news, but now there is a new one: 'global dimming'. What is it and what are its implications for the environment, asks scientist **Chris Jones**?

The term global dimming stems from a number of measurements which suggest that solar radiation at the Earth's surface has been decreasing since the early 1960s. Observations of this were first reported by English scientist Gerry Stanhill who compared solar measurements in Israel from the 1950s to the 1980s. He found a 22% drop in sunlight, but his results were not widely accepted. More recent work by Beate Liepert in the US, and Michael Roderick and Graham Farquhar in Australia, has highlighted the issue again.

Global dimming is mainly caused by tiny airborne particles which reflect the sun's radiation back into space. These particles are called aerosols, and can be either natural or man-made in origin. Some, such as soot, absorb the sun's radiation and hence have a warming effect on the atmosphere. Others, such as sulphates, reflect it and

cool the atmosphere. Furthermore, aerosols can make clouds more reflective and longer lived, causing even more radiation to be reflected back into space. The climate effects of these aerosols have been known since the early 1990s, but now the focus is coming down from the top of the atmosphere to the surface — increased concentrations of aerosols caused by man-made emissions are reducing the amount of the sun's radiation reaching the Earth's surface (see **Figure 1**).

So why has global dimming not had a major impact on our climate? There are two reasons. Firstly, any possible effects of dimming have been overridden by the other impact of mankind's pollution: warming caused by greenhouse gas emissions. In particular, emissions of carbon dioxide, methane and nitrous oxide have led to the climate getting warmer rather than cooler during the last

century. Secondly, even though all aerosols contribute to the dimming they do not all have the same climatic effect. Some have a warming effect on the atmosphere and some a cooling. Although the net effect is widely believed to be a cooling, the magnitude is less than the dimming itself may imply. For this reason, the strength of the dimming is not a precise measure of the strength of the aerosol cooling.

Is it as sinister as it sounds?

While some claim that the dimming may have contributed to the drought in central Africa in the 1980s — the Sahelian drought — this is still highly speculative. Although it is possible that regional patterns of surface cooling due to aerosols contributed to a southward shift of the African monsoon, which impacted on Sahelian rainfall, other factors are likely to have been more important — such as the natural variability of Atlantic ocean currents — although there are suggestions that their link to the sub-Saharan climate has weakened recently. It is also likely that land degradation from over-farming may have left the area more vulnerable to drought and may even have amplified the prevailing drought conditions.

We know that man-made aerosols will decrease in the future, even if carbon dioxide levels continue to rise. Already the adverse environmental and health affects of aerosols — they have been found to contribute to acid rain and severe respiratory and cardiovascular diseases (see pages 11 and 12) — have led to clean air legislation. Technologies such as low sulphur petrol, and 'scrubbers' in power stations, used to remove sulphur dioxide, are reducing aerosol emissions. UK emissions of sulphur dioxide have reduced by a factor of six since their peak in the early 1970s. This very necessary cleaning of the atmosphere has the by-product of reducing the cooling effect of the aerosols. In fact, there are recent indications that the dimming trend has reversed at some locations.

So far, we have been simultaneously warming and cooling the climate, a bit like driving a car whilst pressing the brake and the accelerator. Now we are taking our foot off the brake, but we do not know how fast we will go. We can't tell how strong the greenhouse warming is, even if we know how much the temperature has risen, because we don't know how strong the historical cooling by aerosols has been. If global dimming implies that the aerosol cooling has been stronger than previously thought, then the climate may be more sensitive to greenhouse gas forcing. Could this mean that global warming will be faster and more severe than expected?

In other words, not only do aerosols obscure the sun, they obscure our ability to precisely predict future climate. This indirect effect on our knowledge and ability to plan for the future, as well as the direct effects on health and climate, may prove to be the real danger of global dimming. Are we, as a global society, bright enough to see through it? Or are we just too dim?

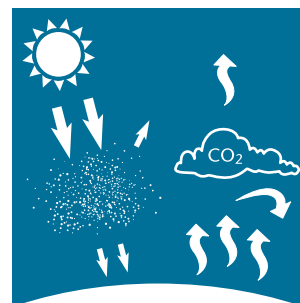


Figure 1: Aerosols in the atmosphere absorb and reflect some of the incoming solar radiation, thus reducing the amount which reaches the Earth's surface. Their effect on clouds also contributes to this reduction. Meanwhile, greenhouse gases such as carbon dioxide trap some of the heat radiated by the planet, thus warming the climate



Chay Blythe

During almost 40 years at sea, Sir Chay Blythe has won many of sailing's highest accolades. Here, he talks about how the weather remains a constant challenge to any sailor.



Twelve racing yachts are currently battling it out in this year's Global Challenge, following a route that takes them around the world in a westerly direction. It is a route that follows in Chay Blythe's wake, as in 1971 he sailed single-handedly, non-stop around the world in 'the wrong direction' (or against prevailing winds) in a voyage that was described by The Times as "the most outstanding passage ever made by one man alone". It won Chay the recognition of the worldwide sailing community; he was voted Yachtsman of the Year by the Yachting Journalists Association and, in recognition of his achievement, made a Commander of The British Empire (CBE).

As a paratrooper in 1966, Chay was no stranger to surviving extreme weather, having braved most conditions from arctic to desert. But it wasn't until his canoeing friend Captain John Ridgeway mentioned he was looking for a companion to join him on an expedition to row across the Atlantic that Chay got his first taste of the high seas.

On that crossing, the two men had little experience or equipment — they didn't even have a barometer — but they made up for it with guts and initiative.

Chay says: "At one point, we knew a hurricane was coming so we lashed everything down and got some rest. Then, at about 11 pm, it hit. I held onto the Samson post (where the mooring rope is tied) as a huge wave broke over us, putting the whole boat underwater for a few moments. When you're in a rowing boat in a hurricane in the middle of the ocean, you've got to keep a sense of humour."

Chay, it seems, was hooked on the challenge of the oceans and went on to win several sailing races — including the Round Britain Race in 1978 and the Two-Handed Trans-Atlantic Race in 1981 — and successfully skippered many more. Then, in 1989, he founded the Challenge Business, enabling

ordinary people to sail around the world with an experienced skipper in a professionally organised race.

The weather, however, can catch out even the most talented and determined sailor. In 1984, Chay faced merciless conditions during a New York to San Francisco record attempt, when he and companion Eric Blunn capsized off Cape Horn and then spent 19 hours in the water before being rescued.

Chay was below decks when a hurricane hit while Eric took his shift at the helm. He says, "I had seen four to five hurricanes before, but when I came up on deck I said to Eric: 'don't look round'. Of course, that's the first thing he did, and behind him were what I can only describe as legions of vast, endless waves, crashing down and then building up again."

Cape Horn is known for its rough seas. It has a seabed that drops suddenly, creating incredibly powerful and steep waves, notorious for swallowing ocean-going vessels. After so many hours in some of the roughest seas on the planet, did Chay ever think his time had come?

"When facing bad weather, you accept you're going to get wet and just have to keep your spirits up. I thought we would last about five days and then we had better start saying our prayers."

Chay believes that anyone taking to the oceans should take as many precautions as they can and make sure they have all possible information about the weather at their fingertips. In Chay's words, "It's a rash skipper that doesn't keep one eye on the barometer and one on the skies ahead."