barometer

Issue 1 www.metoffice.gov.uk **Met Office magazine**

SAFER SEAS
The vital role of the coastguard in a treacherous sea rescue

COLD AIR
How airlines combat frosty conditions

PLEASURE DOME
Tim Smit reveals the secrets of Eden

Barometer is a controlled circulation magazine distributed free of charge to decision-makers in government, science and commerce, for whom weather and climate information has an impact.

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A new direction

Welcome to the new corporate magazine from the Met Office. Its aim is to inform all of our business partners, research associates, government colleagues and customers of the impact of meteorology on people's lives.

The Met Office is a public sector agency and, as such, is responsible for advising on government policies, especially in the area of climate change. As the UK National Meteorological Service, we are also concerned with protecting the natural environment at home and abroad. Overall, our focus is on increasing public safety on land, at sea and in the air; which includes helping people and societies cope with climate-related and other natural disasters, such as the earthquake-tsunami in south-east Asia.

➔ **David Rogers** Chief Executive

The scale of the relief operation still to be undertaken in the countries affected by the Boxing Day tsunami is enormous. The Met Office is assisting rescue and recovery activities by supplying weather information to the governments, agencies and charities involved. In the longer-term we will be looking at ways in which the international meteorological community can better coordinate the transfer and use of environmental data on the Indian Ocean and, indeed, elsewhere. In helping to put in place these early warning systems, our priority is to prevent loss of life occurring again as the result of a natural disaster, particularly on the scale that we have recently witnessed.

Everything we do today is about partnerships and collaboration. To meet our international and scientific obligations we must maintain the close, collaborative links with, for example, UN bodies like the World Meteorological Organization, as well as other national met. services and academic organisations around the world.

Where I see, in the future, the Met Office may work differently is in the commercial arena. We are a public sector agency and our website address — www.metoffice.gov.uk — has recently changed to reflect this. As you will see from some of the features in this issue, this new direction is already having an impact right across our operations.

Thank you to everyone who sent us feedback about the trial edition of our new magazine. *Barometer* is one of the many ways in which we aim to maintain the close links we already have with many of you, and hopefully foster many more. I hope you enjoy reading it and please feel free to feed back any comments you have to our Customer Centre on 0870 900 0100 or via enquiries@metoffice.gov.uk

Building awards

Completed at the same time as the 'Gherkin' in London (the offices of Swiss Re — a capital and risk management company) our new headquarters in Exeter has also attracted some attention. After four years of careful planning, design and building, it has won the Major Project of the Year and Best Office Building of the Year awards, jointly staged by *Building Services Journal* and *M+E Contractor*. In addition, it has received the Considerate Contractor Gold Award, along with the RoSPA Gold Award; and our construction partner, Costain-Skanska, has picked up the *Contract Journal* Public Private Partnership of the Year Award.

Image right: Met Office headquarters interior
Courtesy of Broadway Malyan Architects
Photography: Morley von Sternberg

What's in a name?

Many thanks to everyone who sent us feedback about the trial issue of our corporate magazine. One of the changes made following readers' comments, was to rename the magazine *Barometer* — from its earlier title *metmag*. We hope that you like the changes we have made to this issue. Please keep your thoughts coming in.

Supercomputer expansion

The Met Office is set to double the power of its new supercomputer in April. Technology has come a long way since our first supercomputer, the Cyber 205, was installed in 1981 and took up a whole floor of our former headquarters in Bracknell. Our current supercomputer, the NEC SX-6, already has six times the computing power of its immediate predecessor — the Cray T3E. The upgrade will mean better resolution and allow us to run more complex forecast and climate models.

1981 **Cyber 205**

2005 **NECSX-6**
The NECSX-6 is 10,000 times faster than the Cyber 205.

Keeping drivers safe in winter

A joint initiative from the Met Office and the Highways Agency is helping drivers on England's roads be better prepared for wintry conditions this year.

For the first time ever three forecasters from the Met Office are working at the Highways Agency's National Traffic Control Centre (NTCC) near Birmingham, alongside Agency experts. Together they are providing daily updates on impacts of weather — especially severe weather — on the road network to help drivers plan their journeys.

Keeping the roads safe and open to traffic is the priority. Archie Robertson, Chief Executive of the Highways Agency, said: "We stand ready to keep the network open and available during poor weather."

Drivers are also being advised to prepare for cold weather by keeping a 'winter kit' — including warm clothes, food and a spade – in their cars and, when severe weather strikes, not to drive unless they have to.

Severe weather advice

Ever wondered what to do when severe weather is on the way? The Met Office can help. Our service at www.metoffice.gov.uk/weather/europe/uk/advice/index.html provides advice to members of the public in the event of severe weather. Delivered in partnership with a number of key organisations — such as the Environment Agency, Highways Agency and the Building Research Establishment — the website highlights simple precautions that individuals can take to protect themselves during gales, snow, dense fog, heat waves and other severe weather conditions.

SeaBritain 2005™

SeaBritain 2005 is a year-long celebration of Britain's relationship with the sea, which has shaped our culture and our history. As a seafaring nation, the sea has been our defence in times of war as well as our major trading link with the rest of the world. Providing peaceful contemplation as well as challenging sport, the sea continues to inspire artists, musicians and writers; and is a magnet for tourists and holiday-makers. It is also a rich source of food and natural resources.

The walks, talks, festivals and exhibitions arranged during SeaBritain 2005 will celebrate all of these links with the sea. At its heart is the Trafalgar Festival 2005, marking the bicentenary of Admiral Lord Nelson's Battle of Trafalgar on 21 October 1805. Considered by many as the most decisive naval battle of all time, the Battle of Trafalgar cleared the seas for the growth of trade. The Trafalgar Weekend of 21–23 October 2005 will commemorate Nelson's last hour.

Founded in 1854 as part of the Board of Trade, our founding head — Vice-Admiral Robert FitzRoy (1805 – 1865) — was born in the same year that Nelson died. Earlier in his career, FitzRoy had captained HMS Beagle on a surveying mission to the South American coast. He was accompanied in 1831 by Charles Darwin, whose findings were published several years later in the *Origin of Species*. Using the new-fangled electric telegraph to gather weather data and issue forecasts, FitzRoy expanded the role of the Met Office. By 1861, the first storm warnings were being issued and daily weather forecasts published in *The Times*.

➔ www.seabritain2005.com

Photography: Mark Pearson, Apex

Key environmental events

The New Year sees the world coping with one of the worst natural disasters in human history. The earthquake–tsunami in the Indian Ocean impacted on many countries across south-east Asia, devastating the north-west of the Indonesian island of Sumatra. Across the affected countries, more than 150,000 people lost their lives and many more are sheltering in refugee camps. The Met Office is supplying weather information to the governments, agencies and charities involved in relief operations. We are also working with the international meteorological community to find ways to communicate vital environmental data more quickly in future, across the globe, to warn people of impending natural disasters.

Early January 2005 brought very active winter storms to the north-west of the UK. Three people were killed and some 2,500 homes were damaged in Carlisle following heavy flooding, after 226.6 mm (nine inches) of rain had fallen in parts of Cumbria over three days — the equivalent of the quantity expected during a month. During the night of 11 January gusts in excess of 100 mph brought further loss of life and disruption in Northern Ireland and the north of Scotland.

Last year saw many other severe weather events in the UK and across the world. Parts of the Cornish village of Boscastle were washed away by floods on 16 August 2004. The cause was a series of thunderstorms which developed in a narrow line near the north coast, causing vast quantities of water to thunder down river valleys into the village. A hundred people were rescued by helicopter. At nearby Otterham, a rain gauge recorded 200.4 mm (eight inches) during those 24 hours — almost twice its monthly average rainfall.

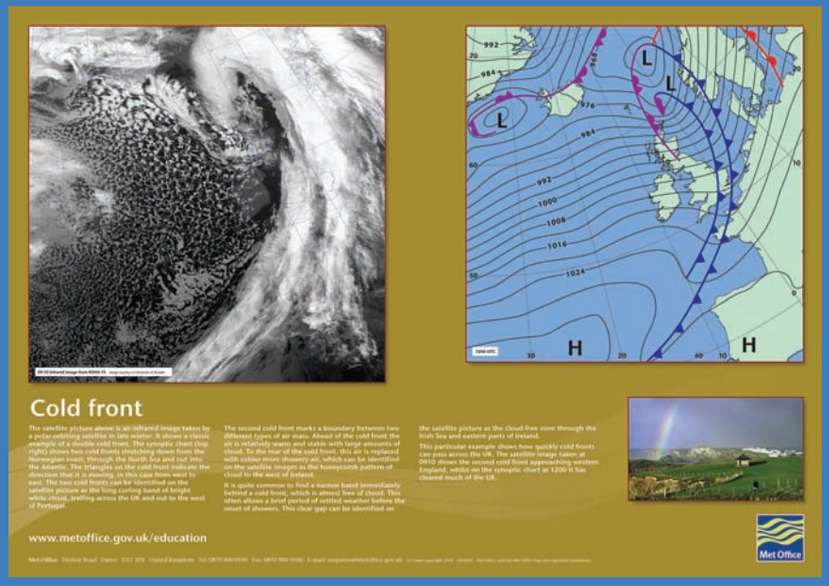
Unusually, a hurricane developed in the South Atlantic basin on 28 March 2004, coming ashore at Santa Caterina in Brazil and causing widespread damage and loss of life. As hurricanes typically do not form south of the equator in the Atlantic Ocean, the local community was ill-prepared.

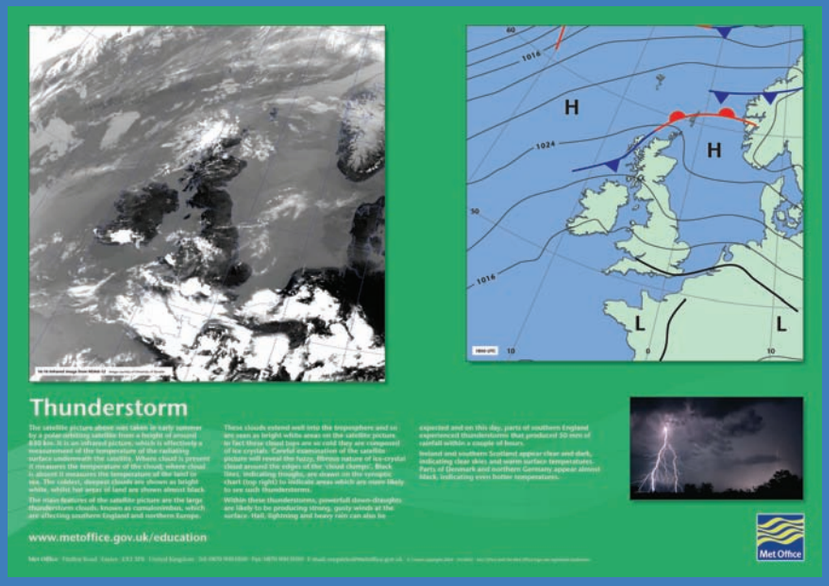
As the hurricane season progressed, residents in Florida found themselves bombarded by four hurricanes and one tropical storm in quick succession. During this more active than normal season, nine named storms affected the whole of the US, as a strong region of high pressure over the western Atlantic steered the storms towards the mainland rather than out to sea.

In Canada on 12 July 2004, a summer storm brought hailstones the size of golf-balls raining down on Edmonton. A few days later, it snowed in Calgary, when daytime temperatures only reached a high of 2.5°C (36.5°F).

Hurricane Frances approaches Florida, 3 September 2004

Japan's tropical cyclone season was the most active on record. Typhoon Ma-on in October 2004 was the ninth tropical cyclone to hit Japan, beating the previous record of six. This was due to dominant high pressure systems forcing tropical cyclones northwards, rather than allowing them on a more westerly track.





Education satellite poster

School children are now able to learn even more about the weather, thanks to new Met Office teaching aids funded by the Department for Education and Skills. The Met Office has produced a set of colourful satellite posters designed to help teachers and students identify common weather situations. Aimed at secondary level, each poster includes a dramatic satellite image, synoptic chart and descriptive text for weather situations such as thunderstorms or a cold front. The DfES funds the Met Office to provide materials and information relating to meteorology, in order to support teachers and their pupils' learning. This includes an enquiry service, development of new resources, such as the satellite poster set, and continual improvements to the dedicated education area of the Met Office web site. Our work with DfES and schools will be featured in a future edition of *Barometer*.

➔ To order set of four A2 posters contact our Customer Centre on 0870 900 0100 or enquiries@metoffice.gov.uk



Improving the military advantage for the armed forces

QinetiQ

"The potential benefits for the military are enormous."

When you are running a military operation, you have to take computer security very seriously. The defences used by normal businesses simply will not do. The UK Armed Forces, for example, have to use a network that is completely self-contained so that no information leaks out and nothing unwanted gets in.

A key issue is how to make environmental information, vital to all military operations, available to the Armed Forces no matter what computer systems they use. Importantly, this information needs to be accessible wherever and whenever it is needed.

This requires a system which brings together, in a useable format, all information about the environment — including the weather — to give a clear picture of the battlefield. Quick and easy access to this information is then essential for all key MoD decision makers — whether they are in an HQ, aircraft or tank — to assess how it may affect operations.

Cutting edge technology

Experts from the Met Office and QinetiQ — the specialist defence research organisation — have been working closely with the MoD to develop such a system. The team have been looking at ways of storing weather data so that they can be used at any time, by whoever needs them. The outcome is JEDDS — the Joint Environmental Dynamic Data Server.

Patrick Sachon, from the Met Office explains: "We are working on a way for users — for example, mission control — to request environmental information as and when they need it. Their systems would then ask the database for the relevant information, improving the speed at which this is relayed to the Armed Forces and, through this, their military advantage."

Alan Bagshaw, from QinetiQ, adds: "The potential benefits for the military are enormous. Mission effectiveness will be dramatically improved as the Armed Forces have readily available, coherent weather information when planning and undertaking operations. The initial project was a technical demonstration of an idea and we've proved that it can be done."

Phil Hopwood, Assistant Director within the MoD, concludes: "JEDDS fits in well with the Future Defence Environmental Capability, where delivery and exploitation of this type of digital information is definitely the way forward."

Although the JEDDS technology has only currently been proved to work in the defence arena, it may also have civilian uses in the future, since it can provide data in whatever electronic format is requested.

Steve Palmer

Holding out a helping hand

“The focus is on protecting people.”

Steve is in back row, 2nd from left

Steve Palmer is a man with a mission — to help developing countries battle poverty, build their economies, protect their people and save lives.

As Steve runs much of the Met Office’s contribution to the World Meteorological Organization’s Voluntary Co-operation Programme (VCP) he spends a lot of time abroad — especially in Africa.

Supporting role

The work of the VCP involves providing support to the met. services of other countries in the form of equipment, services and training. This support is volunteered by WMO members. Some major projects are supported through direct financing by a number of members.

Steve explains the WMO role: “The focus is on protecting people and their livelihoods. We could be helping them save lives by being ready for natural disasters, or simply by using meteorology to improve things such as agriculture, grain storage or transport facilities.”

Steve has been a meteorologist since he started as an amateur while still at school. He joined the Met Office in 1969 as an observer, took a degree and has since worked in many different roles, most of them connected with computers and data analysis.

Computing change

It was his expertise in computing which led to him first being sent to work in a developing country more than 10 years ago. In 1990 Steve was posted to Uganda for nearly three years. His task then was to implement computing and communications equipment at the Ugandan Met Department.

“It opened my eyes to the needs of developing countries. I thoroughly enjoyed my time in Uganda. I was working with wonderful people although I did get frustrated with the sheer difficulty of actually achieving anything.

“With hindsight, it was not really essential for me to be out there so long. It is better to enable people locally to manage the projects themselves. They are the people who are going to be using the equipment and need to make it work.”

Since 1999 Steve has been the International VCP Co-ordinator, and has so far visited 11 of the 53 African countries. He says a typical problem in developing countries is where someone has come along and installed a system for them but now it doesn’t work, and no-one knows how to fix it.

“Ownership by the people using the system is essential to keeping it working, and this starts with listening to the users. Our focus now is a lot more on empowering people.

“My role is to provide management, guidance, feedback, suggestions and support. I help to draw people together from different areas and manage projects. What I dislike most is bureaucracy. That’s the main problem we encounter. You can waste an awful lot of time getting the right piece of paper signed by the right person.”

Wild weather

The other problem he has encountered is more to do with the country’s wildlife than its infrastructure.

He explains: “The WMO Present Weather code — the code used by observers to say what the current conditions are e.g. rain, fog — has an entry for almost every type of phenomenon except ‘visibility obscured by insects.’ At certain seasons in Entebbe, Uganda, there are swarms of lake-flies, and they can reduce the visibility to 50m — like a brown fog. They are harmless, though they give you a sore throat if you swallow them.”

Although Uganda has special memories for Steve, his biggest pleasure is helping the meteorologists in all the countries he has visited — showing them the possibilities of what can be done and then seeing their ideas expand. And if he has to eat insects while he’s doing it he doesn’t mind.

The UK, through the Met Office, actively supports VCP and works closely with other national met. services around the world to:

- Improve protection of life and property from the effects of natural disasters.
- Rapidly restore the life-critical services provided by national met. services whose countries have been affected by natural disasters, or are emerging from conflict.
- Improve understanding of the effects of global climate change by taking new climate observations and archiving existing records of countries which cannot support these activities themselves.

“I recommend deep-fried grasshoppers, very tasty, though I am not keen on termites,” he says.

“Everywhere I have been in Africa, I have been amazed by the hospitality and generosity of the people. The best reward for me is when you see people realise that they can do it for themselves and they don’t have to rely on other people to make things better.”

It's never too cold for take off

Picture the scene: it's the middle of winter, you get into your car first thing in the morning to find the windscreen is frozen over. You find yourself hurriedly scraping the ice away so you can get to work on time. Now imagine you run an airline. Instead of car windows, you have an entire aircraft to de-ice, knowing it's not safe to take off until every bit of the plane is ice-free, from the wing tips to the tailfin.

And of course, as travellers, the thing we want most from an airline is punctuality, rather than hearing our flight is delayed due to cold weather. The amount of behind-the-scenes work that goes into keeping flights on time — despite various weather conditions — is enormous.

Airlines use special de-icing equipment and chemicals, which is an expensive business and a very difficult one to manage. If you de-ice too early, you might have to do it again before take off. If you leave it too late, you might not get all your aircraft cleared in time for take-off. To make matters worse, the timings involved vary according to the precise weather conditions. So what the airlines really need is a way to plan for icy conditions and get their flights away on time.

Improved service

And that's something which Jamie Redjeb, who works in operations for bmi at Heathrow, says the new de-icing service from the Met Office definitely achieves: "Before we had this system we would get a general icing warning and our handling agency would heat up the de-icing rigs. Using the new Met Office system, we're able to give them better information and so cut out the need to warm up the rigs on a 'maybe'. Now we do it on a 'probably'."

Using the customised forecast allows bmi it to be much more scientific and gives a better idea of when de-icing fluid will be required. This means the fluid is not heated up if it isn't needed, which saves time and money, as it can only be heated so many times before it has to be thrown away. At a cost of 500 – 2,500 per plane for de-icing, that can amount to considerable savings across an entire airline.

Jamie says: "We use the system to pre-empt and pre-plan for any kind of icing conditions we might get on a daily basis. When we started using this system, there was a noticeable reduction in delays due to the de-icing warnings. Having better information means we can improve punctuality."

Time means money

Shay Warren, deputy director of operational control at Ryanair, who were involved in developing the service, says: "As a budget airline we have very short turnaround times. Any disruption can have serious knock-on effects throughout the day. We also operate out of some airfields which are not open 24 hours. They don't always have the same kind of coverage and numbers of staff you find at an international airport. When the weather is going to be bad, we need to know so we can alert the airfields that they need to take action.

"It is hard to quantify exactly how much money this service can save airlines, because it's hard to put a cost on a potential problem which hasn't happened. It allows companies to make their own decisions based on good scientific information, rather than on third hand information. But it's not just about money and flight times. It's also about people. The new system means passengers and staff are better informed about what to expect."

“ ...our operational efficiency has improved considerably.”

Fact file:
bmi

- Operates more than 2,000 flights a week
- Has fleet of 55 jet aircraft
- Shortest flight is 55 minutes from Heathrow to Manchester
- Started as Air Schools Limited training RAF pilots in 1938
- Has an annual turnover of more than £770m

Fact file:
Ryanair

- Is the No.1 on-time major airline operating to/from the main UK airports
- Flew 29 million passengers in 2004
- Operates 155 routes to 17 countries
- Uses Boeing 737-800 aeroplanes
- Has an annual turnover of more than £750m

What is the de-icing service?

The new de-icing service from the Met Office gives advance notice covering a 24-hour period with detailed guidance on timing and severity of icing. It also gives an indication of the type of precipitation expected over the next 24 hours, because snow, hail and rain all have very different impacts on an airline’s operations. The service makes detailed predictions for the time window between de-icing and when an aircraft must be airborne or de-iced again.

For more information contact the Customer Centre on 0870 9000100 or enquiries@metoffice.gov.uk

Photography: Terry George

For those in peril on the sea

‘Safer lives, Safer ships, Cleaner seas’ is the motto of the Maritime and Coastguard Agency (MCA). As an island race it is inevitable that our lives often become entangled with the sea, but for the MCA this entanglement can end up being a matter of life or death. The forces of nature, unpredictability of the seas, and the vulnerability of the crafts that sail on them mean the MCA is constantly helping mariners who end up in difficulties.

When the RMS Mulheim ran aground near Sennen Cove in Cornwall on March 22, 2003, following an accident in the wheelhouse, the first priority was to rescue the crew. Despite high seas that were crushing the ship against the rocks, the Coastguard Cliff Team managed to airlift the crew to safety. But that was just the beginning.

The ship was carrying 2,200 tons of plastic and drums of paint that would cause severe pollution if left to spill into the sea. Salvage teams were called in to decide if the ship could be saved. The local community and organisations such as Surfers Against Sewage lent their support to minimise the pollution.

The fierce weather was relentless and there were increasing fears that the vessel would break up on the rocks. Was it safe to launch a salvage operation, which involved putting people back on the boat and constructing a conveyor belt from the ship to the cliff-top?

Difficult decisions

Speaking at the time Robin Middleton, the Secretary of State’s Representative in Maritime Salvage and Intervention (SOSREP), warned: “All our efforts over the next few days will be to remove the cargo from the hold of the vessel before the bad weather closes our actions. However, we are expecting some cargo to escape into the sea

11 August 2003 Sennen Cove >018


10 September 2003 Sennen Cove >06


10 September 2003 Sennen Cove >07


10 September 2003 Sennen Cove >08


31 October 2003 Sennen Cove >01


31 October 2003 Sennen Cove >02


22 November 2003 Sennen Cove >03


27 January 2004 Salvage >06

through wind and wave action during this operation. When the foul weather comes into the area, and despite our best efforts, it is clear that the vessel will be at the mercy of the sea."

To help the salvage team, specific five-day forecasts for the Sennen Cove area were produced by the Met Office, which included wave heights and wind speeds.

A small weather window identified during the last days of March gave the salvors time to remove smaller items from the ship, but then the weather closed in — bringing more high winds and huge swells.

Damage was caused to both the ship and the salvage equipment and it was becoming obvious that lives could be put at risk if the operation continued.

Finally, eight weeks after RMS Mulheim ran aground the cargo was safely removed.

The weather had caused not only the delay but also resulted in some pollution to the local coastline and the loss of a considerable amount of the salvage equipment. The whole salvage operation cost around £1 million.

The clean-up process was to go on for a number of weeks, but thankfully it was successful.

Critical impact

Whenever there is an accident at sea which could cause major pollution it is imperative that all those agencies involved have easy access to detailed weather forecasts.

Captain Joe Collins, Head of the Navigation Safety Branch at the Maritime and Coastguard Agency, says: "Weather has a critical impact on virtually every operation which is carried out afloat.

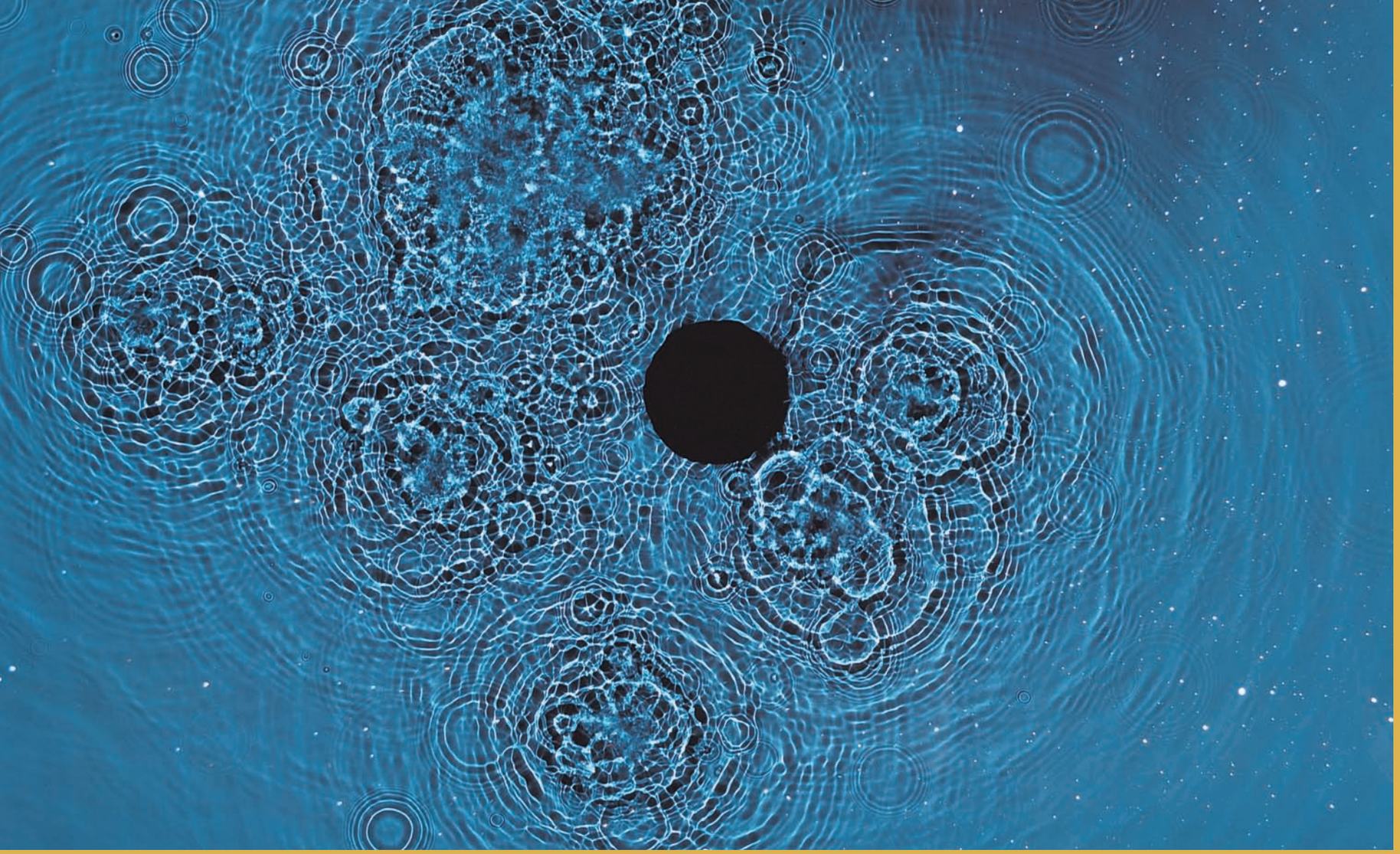
"For the MCA, timely weather forecasts are important because they help us to warn people earlier that they shouldn't be at sea if the weather conditions are unsuitable for their craft. Even with large ocean-going vessels, certain precautions have to be taken to prepare the ship for extreme weather conditions.

"Thankfully, weather-related emergencies are occurring less often, perhaps because people take more notice of our warnings and weather forecasts. That is what we see as the main role of the Met Office to provide the information which helps us keep people out of danger."

For a glossary of terms used in the shipping bulletin, go to: www.metoffice.gov.uk/leisuremarine/shipping/index.html

Did you know?

- The coastguard was set up to combat smuggling.
- Before radio communications, coastguards were expected to read/send 18 words per minute with semaphore flags and 10 with a flashing lamp.
- There is a MCA base at the Thames Barrier.
- In 2002, Falmouth coastguard helped a ship attacked by pirates off the coast of Somalia.
- 97% of the UK's trade by weight is by sea.
- The shipping forecast is issued by the Met Office on behalf of the MCA.



Elemental insight into weather

See it where you are:

2005

> **8 Jan – 12 Feb** Black Swan Arts, 2 Bridge Street, Frome, Somerset

> **5 March – 2 April** Bridport Arts Centre, South Street, Bridport, Dorset

> **9 April – 5 June** Burton Art Gallery, Kingsley Road, Bideford, North Devon

> **18 June – 13 Aug** Canterbury Royal Museum and Art Gallery, 18 High Street, Canterbury, Kent

> **10 Sept – 30 Oct** Derby Museum and Art Gallery, The Strand, Derby, Derbyshire

2006

> **14 Jan – 26 Feb** Falkirk Civic Offices, Callendar Park, Falkirk, Scotland

> **5 March – 15 April** Bury St Edmunds Art Gallery, Suffolk

Hundreds of people around the country have been discovering the synergy between art and science, thanks to an exhibition commissioned by the Met Office.

The Oxford English Dictionary defines art as "the expression or application of creative skill and imagination" and science as "a systematically organised body of knowledge on any subject". By those definitions it would be fair to assume that never the twain shall meet. But the Elemental Insight tour has debunked this assumption. Its whole essence is the fusion of both.

Elemental Insight is an exhibition of the work of 27 artists who are concerned with the natural environment. It is the result of the Art at the Met Office project, set up in 2002 to reflect, promote and debate the activities of the Met Office, through exploring the relationships between art and science. It has already toured much of Devon and is now travelling around the country (see dates above).

As part of the exhibition, four works by Kurt Jackson, Mariele Neudecker, Susan Derges and Naomi Vincent were commissioned by the Met Office, and following a staff vote a number of other works have been purchased. In the Exeter HQ the spacious atrium, known as the Street, is the perfect setting for dramatic art installations and these works will be on permanent display for both staff and visitors to the office to enjoy.

➔ For more details on the Elemental Insight Tour contact Alex Murdin, Devon Guild of Craftsmen, 01626 832223, devonguild@crafts.org.uk

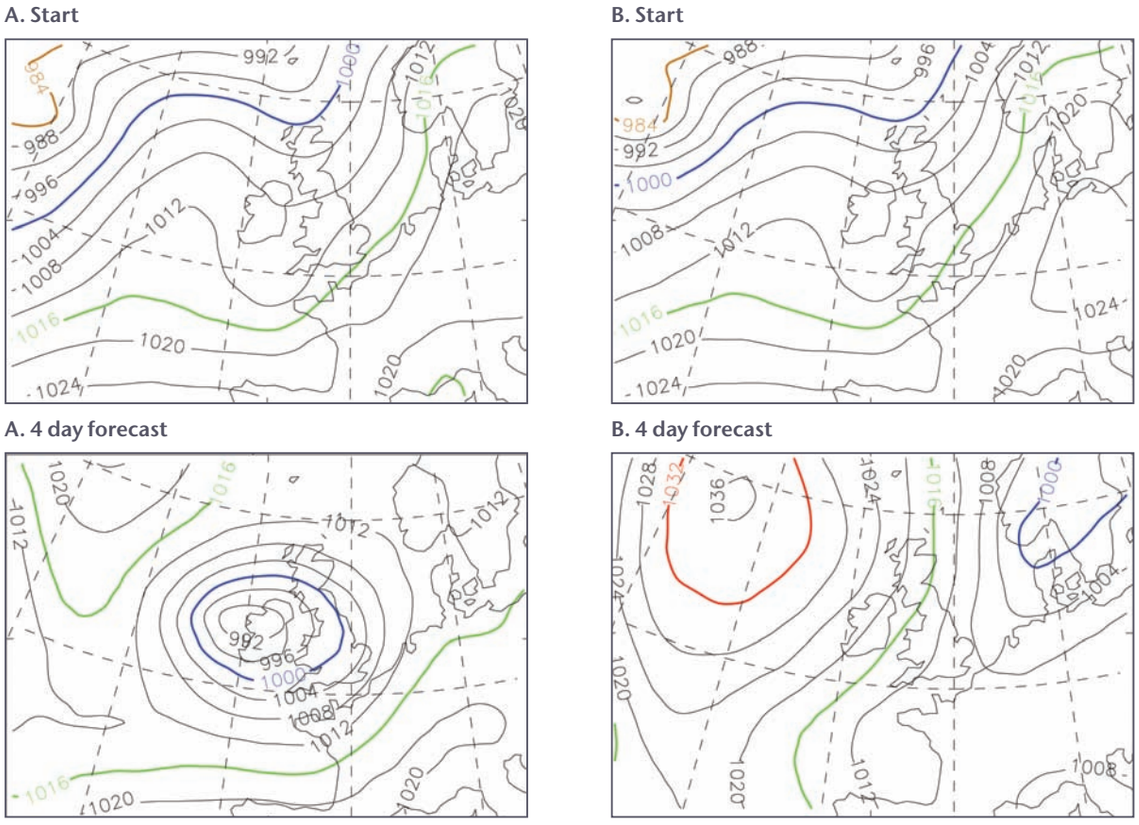


Figure 1. Example of two members of an ensemble forecast at the initial time (top row) and at Day Four (bottom row), illustrating the sensitivity of the forecast to tiny differences in initial conditions

Risk assessment in weather forecasting

By **Ken Mylne,**
Ensemble Forecasting Research Manager

Ensemble forecasts

Everyone knows that weather forecasts go wrong on occasion. For next-day forecasts the errors are usually in the detail, but when we look a few days ahead the chaotic nature of the atmosphere can often lead to large errors. To deal with this, the Met Office uses ensemble forecasts to help measure the uncertainty in every forecast. This means we can turn forecasts into risk assessment tools to balance the potential impact of the weather against the cost of mitigation.

In an ensemble forecast we run our computer model many times from slightly different starting conditions. Initial differences are tiny so each run is equally likely to be correct, but chaos means that the forecasts can be quite different. **Figure 1** shows an example of two typical members of an ensemble forecast which are virtually indistinguishable at the start (top row) but produce very different forecasts for the UK by Day Four (bottom).

For forecasts between three and 10 days ahead we use an ensemble of 51 members run by the European Centre for Medium Range Weather Forecasts. Some days the members may be quite similar, which gives confidence that we can issue a reliable forecast. On other days the members can differ radically and then we have to be more cautious.

"Better assessments of the risks"

Describing uncertainty

Our forecasters use the ensemble to help assess the most likely weather patterns for coming days, and to describe the range of uncertainty and risk of different outcomes. **Figure 2** shows how we can present temperature forecasts for the next 10 days at a given location. The central box for each day shows the most likely range (with 50% confidence) while the whiskers show the 95% confidence range. It is clear that the uncertainty increases further ahead.

To help with risk assessment for high impact weather, we can estimate the probability of defined events. Early warnings of severe weather are issued up to five days ahead as probabilities for different regions of the UK estimated from the ensemble. **Figure 3** shows charts of the probability of wind speed exceeding Beaufort Force 6, 8, 9 and 10 around the British Isles.

Decision-making with probability forecasts

Probability forecasts allow users to balance the likely impact of weather events with the cost of mitigation. Where protection costs are high, the user will only want to act when the

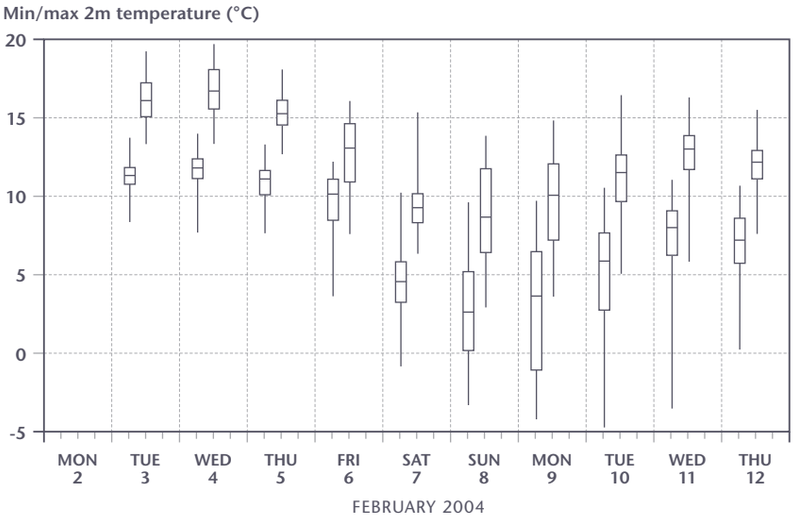


Figure 2. Example of box and whisker plots indicating the range of uncertainty in maximum and minimum temperatures over the next 10 days

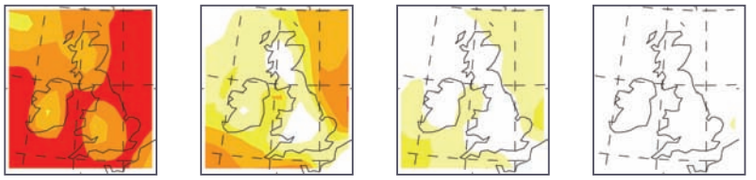


Figure 3. Contoured charts of the probability of wind speed exceeding Beaufort Force 6, 8, 9 and 10. Darker colours indicate higher probabilities

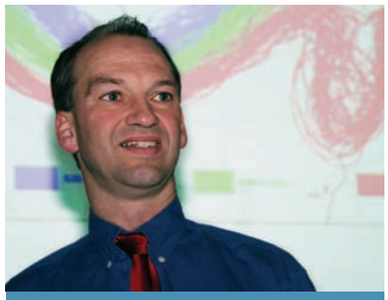
probability is high. However, when the impact is high and protective cost (C) low, it is worth protecting when the probability is quite low. In practice it is often difficult to estimate likely losses (L), but as a general guide a user should take action when the probability of an event exceeds the ratio of protective costs to losses (C/L).

Risk management in short-range forecasts

Current use of ensembles is restricted to medium-range forecasting, but important uncertainty can also occur in short-range forecasts. Up to three days ahead the general weather pattern is usually well predicted, but occasionally, large uncertainty occurs at shorter range. This is often associated with severe weather. More commonly, there can be large uncertainty in details of the weather, such as the amount of rainfall. To tackle this, the Met Office is developing a short-range ensemble system using its new North-Atlantic European model, allowing us to make much better assessments of the risks of high impact events. This system is due to enter operational testing in the autumn of 2005.

➔ For further information visit our website www.metoffice.gov.uk/research/nwp/ensemble/index.html

Science profile



➔ **Ken Mylne**
Ensemble Forecasting Research Manager

The Met Office employs more than 1,800 professionals and experts who are constantly pushing back the boundaries of weather prediction. But what drives them to become meteorologists in the first place?

Ken Mylne's mother always knew he was going to be a weather man. Aged only two, he was already asking: "Mum, why is it raining and sunning at the same time?"

This early interest in meteorology blossomed and became considerably more scientific. After studying physics at Oxford University, Ken joined the Met Office, aged 21, and hasn't looked back.

Strong foundations

After seven years researching atmospheric dispersion patterns, he trained as a forecaster and joined the National Met. Centre, as it was then, the equivalent of today's Operations Centre. It was there that Ken first encountered the idea of ensemble forecasting.

"As soon as I heard of ensemble forecasting, it struck a chord," he says. "I immediately thought 'this is the way we should be doing things'. I had long been interested in the sensitivity of forecasts to small errors, so when I saw a job advertised in ensemble forecasting I applied for it and got it."

That was in 1998. In the years since, ensemble forecasting has come a long way. In those days it was used for long-range forecasts and was being developed for the medium range. Today, medium-range forecasts are based primarily on ensemble output, but the real breakthrough is the advent of short-range ensemble forecasts.

"Ensemble forecasting is one of the ways we are going to push future developments in forecasting," says Ken. "It is about improving risk assessment in forecasting. This turns the weather forecast from a best guess into a true risk assessment tool, and will allow people to make more informed decisions."

The future of forecasting

Ken is now Ensemble Forecasting Research Manager, and runs a team which has been working hard to make these short-term forecasts a reality. They are due to go live in Autumn 2005.

He is also pushing the boundaries further through international collaboration projects.

"The idea is to have multi-model ensembles based on international collaboration. It will help to forecast risks of natural disasters in poorer countries, for example. This could be the beginning of a more collaborative weather forecasting system for the whole world."

Last November, Ken was in Washington for talks with US and Canadian counterparts to move the project forward. Asked if he is looking forward to the prospect of another busy year, he says: "I'm already having a very busy year."

How certain are we about climate change?

You've seen it on the TV and read it in the newspapers, but how much do we really know about the consequences of climate change, discusses climate scientist **Mat Collins**.

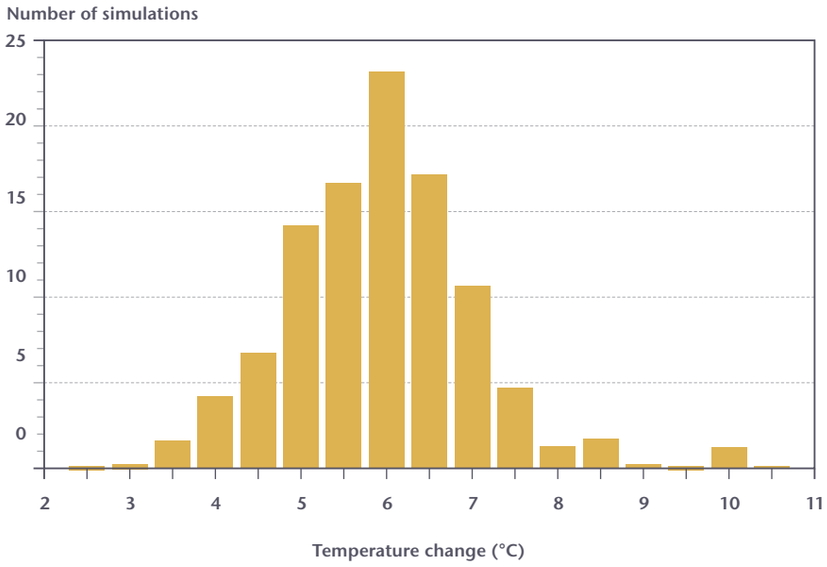


Figure 1. A Met Office histogram of possible winter (December to February) warming over Northern Europe for a doubling of atmospheric carbon dioxide. One hundred different model simulations were performed and the height of each bar shows the number of simulations which fall within the range indicated on the horizontal axis

We know the world is warming, that humans are largely to blame and that it will continue. We know, for example, that global sea-levels will rise and that the number of frost-days will decrease. But we are less sure about the magnitude of these changes.

In the Hadley Centre we continually strive to better observe, understand and model climate change in order to better predict its consequences. But just as in weather forecasting, there are uncertainties in our climate forecasts.

The concept of ensemble forecasting to quantify uncertainty in start conditions has been around for a number of years in weather forecasting (see the ensemble article, p15). However, climate forecasting is a very different beast. Whilst uncertainties in start conditions are again important, of greater importance are uncertainties in the models we use and in the future levels of greenhouse gases which cause climate change. The latter are a consequence of political, economic and lifestyle choices and are difficult to assess. What we can assess is the role of the uncertainties in our models of climate.

The Hadley Centre is pioneering the use of ensemble forecasting in climate change prediction. Forecast models divide the globe into a grid. Each grid-box has a value of all the principal meteorological variables (temperature, rainfall, etc.) and the model is run forward in time taking into account forces which act upon those variables. Also necessary are representations of phenomena which occur at scales smaller than the grid-box (many hundreds of kilometres in the case of a climate model which must be used to predict hundreds of years into the future). These sub grid-scale processes are represented using formulas which include parameters and it is these parameters which are uncertain. We can vary the parameters to produce an ensemble of climate change predictions and a probability forecast.

Figure 1 shows an example of a probabilistic forecast produced in this way. It is of warming in Northern Europe in winter when levels of atmosphere carbon dioxide, the main human-produced greenhouse gas, are doubled. It shows that while the most likely value of the warming is around 6 °C, there is a possibility that it could be as little as 3.5 °C or as much as 10 °C. Some may argue that this is a backward step; are we now even more uncertain? The answer is no. Previously we may have given a 'best estimate' and filed the uncertainties under the heading of 'future work'. Now we have quantified the range, we can focus our attention on reducing the uncertainty and issuing more confident predictions. Those familiar with risk-assessment may also see the possibility of balancing the cost of mitigation against the loss incurred because of changes in climate.

We are taking the first tentative steps in ensemble climate change prediction. Predictions take a large amount of computer time and many scientific, technical, intellectual and communication issues lie ahead of us. The ultimate aim is to produce ensemble probability forecasts for regional changes and for changes in phenomena such as extreme cyclones. This will take time and we must be very careful to take into account all of the uncertainties.

Tim Smit

When you set about creating a tourist attraction in the South West of England, the weather is always going to be a factor. But if you really think big, maybe you can even create your own weather...

On paper, The Eden Project — a multi-million pound dream to build a series of huge greenhouse-like domes in the middle of Cornwall — should never have happened. But the imagination, focus and drive of the project team, led by Tim Smit, somehow turned an incredibly ambitious idea into reality. Of course, there were difficulties along the way, with one of the most notable being the weather.

Tim sums up the challenge faced by the Eden Project, saying: "Plants can't sing or dance so why would people want to come and see them?" But the incredible success of the Eden Project has taken a lot of people by surprise, including Tim himself. The huge site in mid Cornwall is undoubtedly fascinating to keen horticulturalists, but it also makes a great day out for a wide cross-section of the public. The huge biospheres (which are among the biggest in the world) form a stunning backdrop and have turned an old quarry into a futuristic terrain that would not look out of place in a Hollywood sci-fi blockbuster.

Growing pains

The construction of the site was not without its difficulties, partly because of the vagaries of the English weather. Tim explains: "In 1999, when the domes were still under construction, we were hit by an extremely wet winter which saw 43 million gallons of water flooding into the pit. Much of the topsoil that lined the steep walls of the quarry around the domes was washed into the site."

In fact, the deluge was eight times heavier than the engineers had predicted as a worst-case scenario (of which the probability was 1:100). And given that the site sits 30 ft below the water table, it's not surprising the flood delayed construction for six months.

Tim and his team, however, were used to dealing with challenges. After all, they had persuaded people to invest in the highly unconventional scheme in the first place. Thus the flooding was only ever seen as a temporary setback and, in time, was turned into a valuable lesson. They discovered once-dormant streams under the site which led them to develop a highly sophisticated drainage system to guard against any similar weather conditions in the future.

Come rain or shine

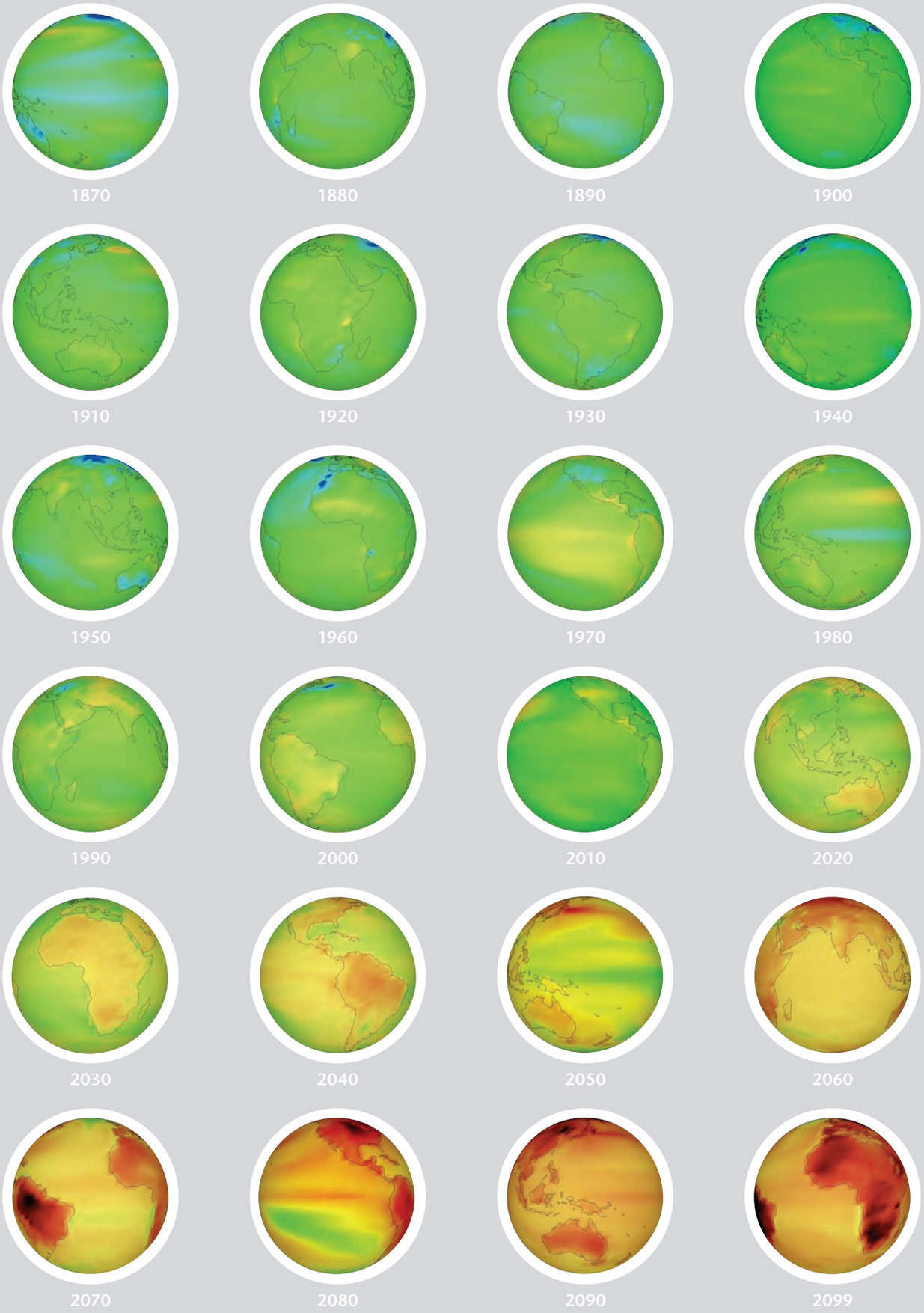
The weather also plays a key part in the ongoing management of the Eden Project. "Weather prediction is hugely important to us, especially in predicting visitor numbers. Slightly cloudy weather is best for us as it draws in loads of tourists," says Tim.

With accurate weather prediction, staff levels can be calculated to meet demand. Although the atmosphere within the biospheres needs to be carefully controlled to give the plants the right environments to flourish, the domes themselves capture enough heat to keep the plants healthy. It's testament to their design that the biospheres only need heating for three and a half months of the year.

Unique weather system

Having found themselves at the mercy of the weather in the past, it seems slightly ironic that the plants at the Eden Project might be able to produce their own weather system in the future. The plants are growing so fast that the tropical dome could have a mature canopy consisting of mahogany and teak, among others, within 30 years. At this point, according to Tim, it is conceivable that the moisture within the domes could form into clouds and that it could even produce rain inside the domes.

Visiting the Eden Project is a genuinely different experience, one that will undoubtedly remain a firm favourite of tourists and horticulturalists well into the future. Its success is down to the energy of Tim and his team, and their ability to bring a dream to life despite the challenges. Tim's fascination with the natural world and how people interact with it is highly infectious. His belief that "weather should be totally important in how people live their lives", is a sentiment that's echoed all around the Met Office.



Temperature rise

A rapidly warming world

Stills from a movie showing temperature rise every decade from 1870–2099 as predicted by the Met Office Hadley Centre's world-leading climate model.

After decades of little change, man-made warming starts to take hold in the 1970s and accelerates rapidly thereafter.

But what level of change is dangerous to mankind? This will be the topic of a major international conference, announced by Tony Blair, to be held at the Met Office in February 2005.