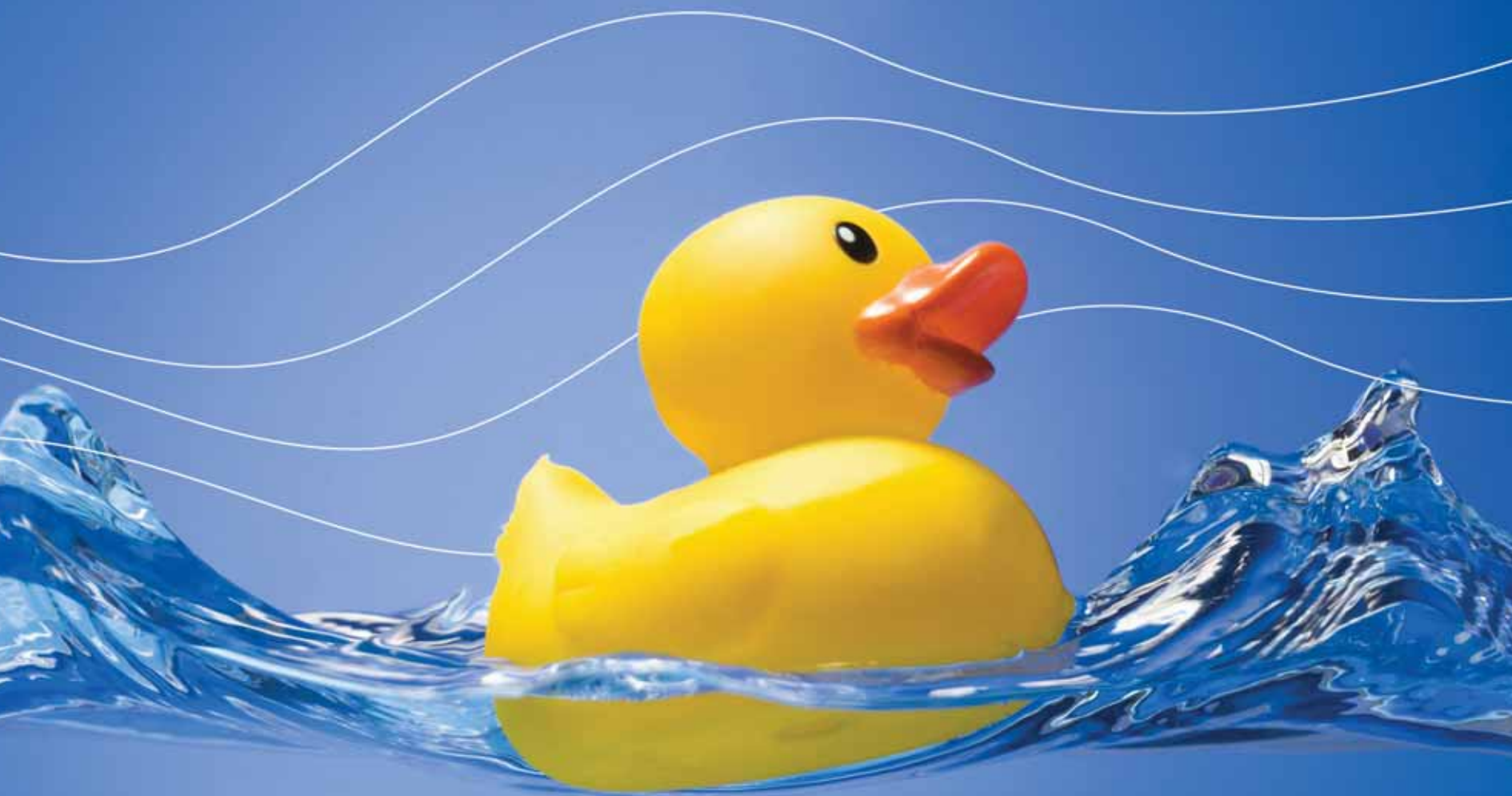


barometer



Issue 6 www.metoffice.gov.uk Met Office magazine



CLIMATE CHANGE

Realising the solutions

FLY RIGHT

Safe and smooth air travel

DUCKS IN A ROW

An ocean odyssey



A sea change



Having provided much of the evidence to measure the effects of climate change, the Met Office is now finding the best solutions to help its customers mitigate and adapt to it, explains **Phil Johnston**, Commercial Business Director.

With 2007 forecast to be the warmest year on record globally, the scientific certainty of a changing climate is irrefutable. Key to helping customers translate climate change science into practicable solutions is Met Office Consulting (pages 7–8) within the Commercial Business area of the Met Office. This team of highly-skilled consultants draws from the expertise of the Met Office Hadley Centre to equip customers with the best weather and climate information there is.

Last autumn, Sir Nicholas Stern published his comprehensive review on the economics of climate change which estimated the UK market for mitigation could be £3.5 billion by 2010. The cost of doing nothing, the review says, could reduce the country's annual Gross Domestic Product by as much as 20%. The time to act is now.

The Met Office predicts that climate change can be stabilised if carbon emissions are reduced significantly. Proposed targets involve reductions of at least 50% by 2050 with further cuts thereafter (page 6). But even with such a dramatic cut in emissions, our scientists say there would still be a need to adapt to some level of climate change as the full effect of past carbon emissions on the world's climate has yet to be realised.

Importantly, Barometer asks what impacts our changing climate will have on society (page 17), reporting that the rapid changes predicted to occur in the 21st century will affect developing countries, particularly in areas where high population growth and rapid urbanisation are already putting a strain on limited resources.

Water is one of the most important natural resources likely to be significantly affected as our climate changes. Last year, the Met Office supported WaterAid — an international charity dedicated to the provision of safe domestic water, sanitation and hygiene education to the world's poorest people (page 5). The World Health Organisation estimates that 1.1 billion people in the world do not have access to safe water. Managing projects to dig trenches, lay pipes and install water pumps and teach people about sanitation, WaterAid is helping to reduce this number where it is needed most.

While Met Office scientists continue to study our changing climate, its consultants can help you get your ducks in a row by planning now for the future. A previous issue of Barometer profiled the work being done by Met Office consultants to help the UK's energy industry scope the impact of climate change on the safe and efficient delivery of energy supplies. Some insurers are already working with Met Office Consulting to produce risk profiles which factor in the extreme weather that is forecast to become more likely as our climate changes.

With ever more powerful supercomputers and modelling, the Met Office plans to study regions in even greater detail in the near future, pinpointing its weather and climate advice to customers to help them mitigate and adapt to the localised affects.

If Met Office Consulting can help you, please complete and return the survey at the back of this issue of Barometer and one of our consultants will be in touch.

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A duck's tale

A container-load of plastic bath toys lost off the back of a cargo ship is offering insights into the behaviour of ocean surface currents.

Back in 1992, during a violent storm in the Pacific Ocean, a consignment of toys was washed overboard from a container ship en route from Hong Kong, China, to Washington on the north-west coast of the United States. The container opened and 29,000 plastic bath toys of various types — including green frogs, red beavers, blue turtles and, of course, the classic yellow ducks — made a break for freedom.

Presumed lost at sea, the castaways embarked on an epic swim across three oceans and half the globe. Somehow, 15 years later, many are still afloat having survived all magnitude of wind and waves and weathering several winters frozen in the Arctic ice floes. Today, beachcombers all over the world are still finding the toys.

They are, in some ways, similar to the Argo floats featured on pages 13–14, used by the Met Office to collect observations from the ocean. Though they are much less technically sophisticated than their Argo cousins, the mass release of 29,000 plastic objects into the ocean at one time is offering insights to scientists.

The toys' journey has been tracked by retired oceanographer Dr Curtis Ebbesmeyer and computer expert James Ingraham who, together, model ocean currents on the basis of flotsam movements. They were already tracking various other spills of flotsam, including 61,000 running shoes, when the toys' adventure started.

The two researchers correctly predicted the arrival of the toys off the Washington State coast in 1996 and

that many would have drifted northwards through the Bering Strait and become trapped in the Arctic pack ice. They also forecast that it would take five or six years of slow movement with the ice across the North Pole, past Greenland and Iceland, for the toys to reach the North Atlantic where the ice would thaw and release them. Meanwhile, they expected a flotilla to head south through the tropics to be washed up on the shores of Indonesia, Australia and South America.

Over the years, beachcombers have patiently recorded the date and location of where the toys were found and reported their discoveries to Dr Ebbesmeyer who incorporated the data into his studies. The toys have also become collectors' items, with more recovered in 2004 than in any other year. At one time, the company that markets the toys even offered a US \$100 reward to anybody who recovered one of the friendly floatees.

After so many years at sea, the ducks and beavers have faded to white from exposure but the turtles and frogs have kept their original colours. Keep a look out — you never know when a breakaway flotilla may make landfall in Britain.



New look website

Your new look Met Office website was launched in November 2006. The homepage and many of the top-level pages have been redesigned while the navigation bar is now consistent across the whole website, making it easier to find the areas that are of interest to you.

Enhancements to our weather forecast pages mean the site now provides even more useful weather information and severe weather warnings. As the weather varies over the day, users can access the latest forecast and see if and when severe weather is expected for their area. Also indicated is the likelihood of disruption caused by the unfolding weather events and advice on what to do. Feedback on these improvements has been overwhelmingly positive.

With such a complex site, a programme of content management is continuing after the launch and further improvements are planned. Let us know what you think by submitting your comments to www.metoffice.gov.uk



Weather to go

A presentation by Met Office and BBC weatherman Phil Avery at the London Boat Show in January 2007 briefed the audience on making the right call when setting out to sea.

In his talk Phil described the benefits of Marinecall, supplier of Met Office marine and sailing weather forecasts via the web, telephone, fax and mobile phone. Marinecall and the Met Office have been working together for almost two decades providing specialist weather forecasts to the public and business customers.

Phil began his forecasting career in the Royal Navy and served on HMS Ark Royal. Drawing from his sea-faring and forecasting experience he took part in the Global Challenge yacht race in 2004. This high-sea adventure, which saw him sail the 'wrong way' around the world against the prevailing winds and currents, featured in Barometer later that year.

With his first-hand experience of how vital accurate and timely marine weather forecasts are for safe and enjoyable boating, in his talk Phil explained how weather forecasts are compiled. He also described how free and paid-for services from the Met Office, including Marinecall, complement each other and can help mariners and leisure sailors plan their time on the water.

Special Ops

In January 2007, the Met Office officially opened a new look Operations Centre at its Exeter headquarters. The ceremony was attended by Met Office Chairman, Robert Napier, who commended the changes.

The 'Ops Centre', as it known among staff and customers, is key to many Met Office products and services. Following a programme of centralisation, it accommodates highly-trained forecasters — experts in producing the world-class weather forecasts for which the Met Office is renowned. The Ops Centre, Exeter, also includes the Customer

Centre on 0870 900 0100 and Met Office computer experts, while the Ops Centre, Aberdeen, will soon be unveiled after refurbishment.

Services such as BBC television weather and the Shipping Forecast are informed by forecasts produced by these twin Ops Centres, as are other services critical to safety in the sky and at sea. Barometer looks at how the Met Office is working with the aviation industry to keep air travel safe and flights on time (pages 9–10). It also touches on some of the marine services operating out of Aberdeen (page 15).





Winter warmer

The Met Office temperature figures for 2006 showed that mean near-surface air temperature continued to exhibit a warming trend around the globe and especially in the UK. The Met Office with the University of East Anglia (UEA) maintains a global temperature record which is included in the reports of the Intergovernmental Panel on Climate Change (IPCC). Climate experts at the Met Office have contributed extensively to the IPCC's fourth assessment report, as explored on page 6.

Consistent with this, unseasonably warm weather continued deep into December and much of January. Rainfall was also well above-average in most regions of the UK with prolonged spells of wet weather and strong winds. The Environment Agency (EA) issued several flood warnings for Wales and the

south coasts of England, the latter due to a combination of strong winds and high tides. The Scottish Environment Protection Agency (SEPA) also dealt with many flooding incidents, particularly in the Glasgow area where previous rainfall records for late autumn were broken. Partnerships between the EA, SEPA and the Met Office worked particularly well during this period to keep the public informed.

Media attention focused on north-west London early in December as an active squall line spawned a tornado, which caused substantial damage to property. The mild, wet and windy weather continued until a few days before Christmas when conditions turned much more seasonal. However, this change of weather presented a new hazard in the form of thick and, in some places, freezing fog.

Major disruption occurred at Heathrow and some of the regional airports as flight cancellations disrupted the Christmas getaway. By accurately forecasting clearance of the fog, the Met Office provided timely advice to the British Airports Authority which helped it plan in advance to clear the backlog.

In January, the weather changed again and the Met Office issued advance warnings of stormy weather across much of the country, with gusts of 60–80 miles per hour affecting Scotland and Northern Ireland as well as parts of Wales and England. Our forecast for winter 2006/7 (issued in May 2006) previewed the potential for snow events towards the end of the winter period. These were seen in February, with particularly disruptive snow events in the South East and into Wales and the Midlands. Our website exceeded its previous record of 2.7 million page views to around 5 million 'hits' on the day before the first snow arrived.

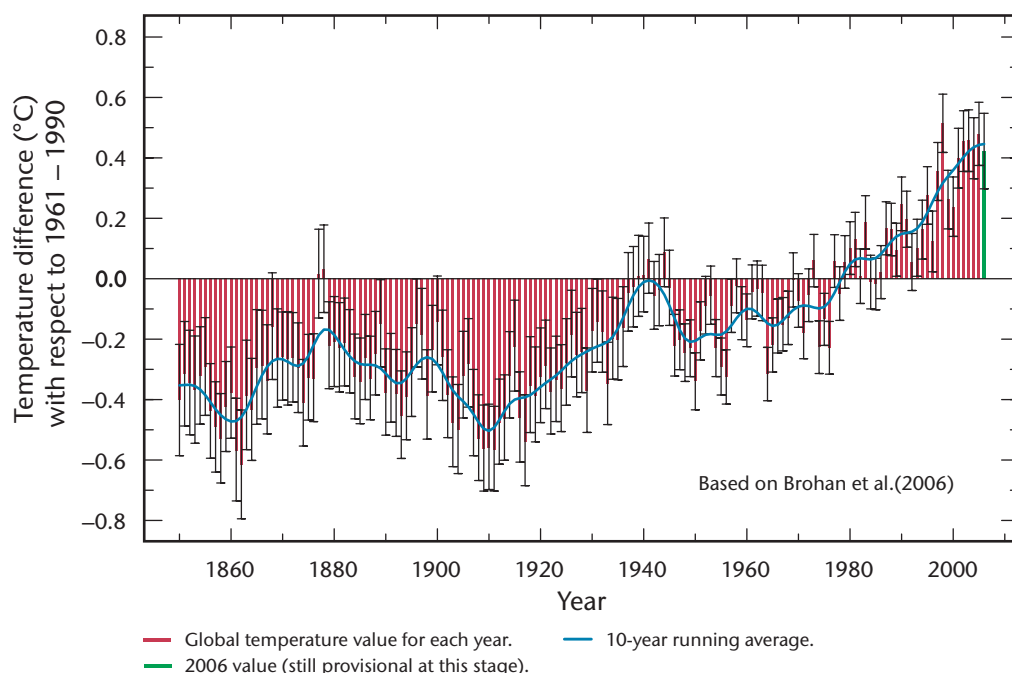
At the start of each year, Met Office and UEA issue a forecast of the global near-surface temperature for the coming year, taking into account known contributing factors such as solar effects, El Niño, greenhouse gases concentrations and other multi-decadal influences. It is predicted that 2007 is likely to be the warmest year on record globally, beating the current record set in 1998.

The potential for a record 2007 arises partly from a moderate-strength El Niño already established in the Pacific Ocean which is expected to persist through the first few months of 2007. The lag between El Niño and the full global near-surface temperature response means that the warming effect of El Niño is extended and therefore has a greater influence on global temperatures during the year.

Met Office Consulting provides data and risk management services that are used by other government departments and agencies, the private sector and the public to mitigate and adapt to our changing climate.

→ For more information visit www.metoffice.gov.uk

Global average near-surface temperatures – annual anomalies 1850–2006





Last Christmas, the Met Office supported WaterAid — an international charity dedicated to the provision of safe domestic water, sanitation and hygiene education to the world's poorest people.

Clean water and sanitation make it possible for people to take the first essential step out of the cycle of poverty and disease. Among its other work, WaterAid funds projects to dig trenches, lay pipes, and install water pumps to get clean water where it is needed most.

The World Health Organisation estimates that 1.1 billion people in the world do not have access to safe water. UNICEF figures show that 1.8 million children die every year as a result of diseases caused by unclean water and poor sanitation. This amounts to around 5,000 deaths each day.

Voted by its peers in the voluntary sector, WaterAid was named Britain's Most Admired Charity in 2006 followed by Save the Children and The Samaritans.

Mark Hutchinson, Met Office Chief Executive said, "Our changing climate will have a greater impact on the most vulnerable. In some developing countries, droughts may become more frequent as the world gets hotter. The Met Office made a careful and appropriate choice in backing a charity that helps give people access to clean and safe water, and teaches hygiene. Staff are delighted to support the work of WaterAid."

→ For more information visit
www.wateraid.org





Taking on climate change

Climate change is happening — now. The Met Office has provided much of the evidence to measure the effects of our changing climate and is now finding the best solutions for mitigating and adapting to it. Today, much of the world is sensitised to this important problem and, in order to take it on, the World Meteorological Organization (WMO) and United Nations Environment Programme (UNEP) have formed the Intergovernmental Panel on Climate Change (IPCC).

Convened in 1988, the IPCC has published three major reports, each of which aimed to present an objective

overview of the scientific, technical and socio-economical facts about climate change at the time — based on research by experts across the globe, including the Met Office. The first instalment of the fourth IPCC assessment report was published in February, with further releases planned for April and May 2007.

Worldwide consensus

The first part of the report (Working Group I) sets out the underpinning science behind climate change, the second (Working Group II) looks at who and what will be vulnerable to its effects and the third (Working Group III) assesses the options for mitigating climate change. Drawing from its wealth of expertise, the Met Office has been involved with every chapter of the Working Group I report published in February and is responsible for editing Working Group II.

“The IPCC has drawn together the worldwide authoritative consensus on climate change. It looks at all the scientific research, brings it together and boils it down into a meaningful and useful statement,” says Dr Richard Betts, head of climate impacts research at the Met Office and a lead author for the IPCC. “The fourth report is probably the most thoroughly researched and reviewed document in the history of science. Ultimately,

people want to know what the implications of climate change are and what to do about it, which is why the Met Office is expanding its remit,” says Richard.

The new Met Office Consulting service is key to this and is working with other government departments and agencies, the private sector and the public to mitigate and adapt to our changing climate.

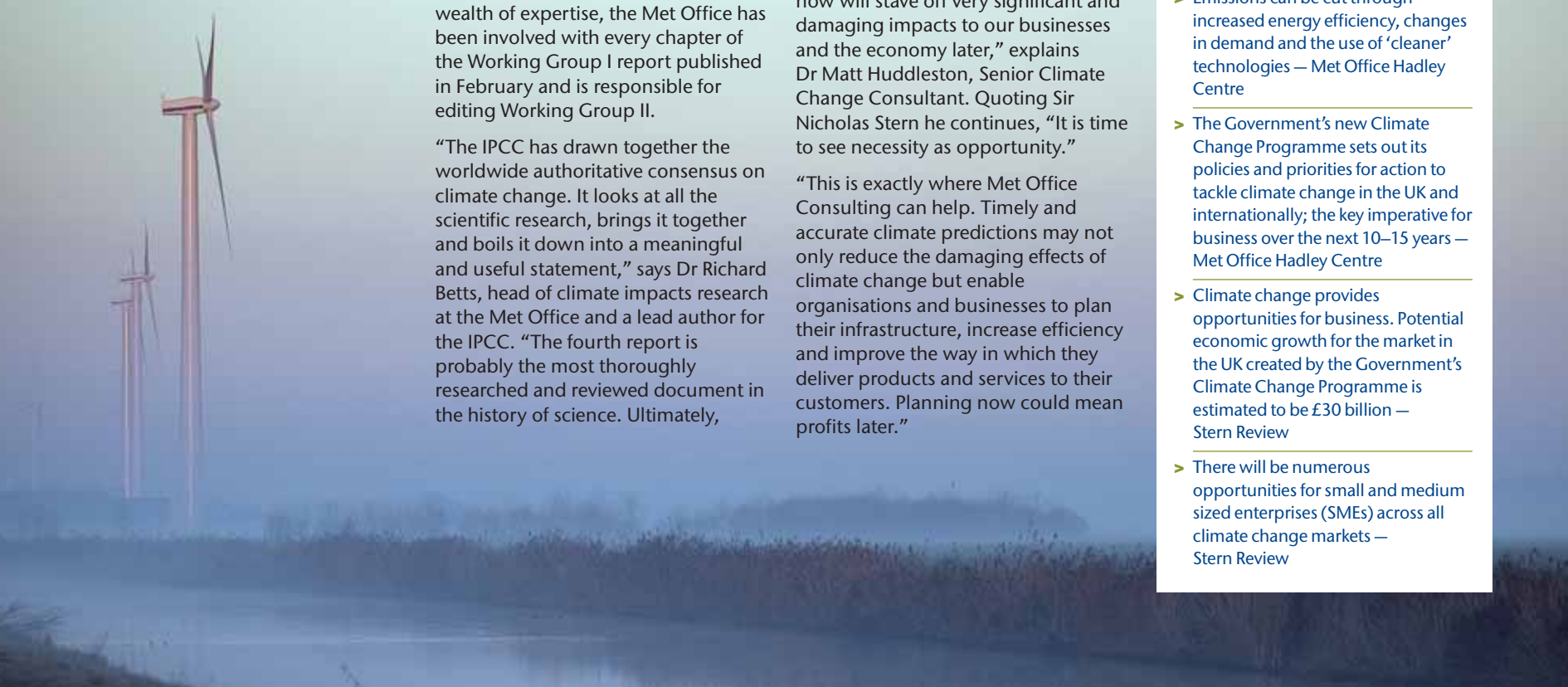
In autumn 2006, Sir Nicholas Stern published his review on the economics of climate change, which estimated that the initial cost of tackling carbon emissions to reduce its affects in the UK would be about 1% of annual productivity or Gross Domestic Product (GDP). However, he also suggested that it could lead to economic growth through adaptation by as much as 2% GDP — and even more than that in the renewables and carbon trading markets. Doing nothing could reduce GDP by as much as 20%.

“The key message was that adaptation now will stave off very significant and damaging impacts to our businesses and the economy later,” explains Dr Matt Huddleston, Senior Climate Change Consultant. Quoting Sir Nicholas Stern he continues, “It is time to see necessity as opportunity.”

“This is exactly where Met Office Consulting can help. Timely and accurate climate predictions may not only reduce the damaging effects of climate change but enable organisations and businesses to plan their infrastructure, increase efficiency and improve the way in which they deliver products and services to their customers. Planning now could mean profits later.”

Summing up climate change

- > Warming of the planet is now unequivocal and indisputable — IPCC WG1 report
- > Climate change may be stabilised if carbon emissions are reduced significantly in future. Proposed targets involve reductions of at least 50% by 2050, with further cuts thereafter — Met Office Hadley Centre
- > It is likely that certain types of extreme climate events (e.g. heat-waves, heavy precipitation, drought) have become more common in recent decades — IPCC WG1 report
- > The full effect of past carbon emissions on our climate has yet to be realised, so even with large cuts in emissions there would still be a need to adapt to some level of climate change — Met Office Hadley Centre
- > If we don't act, the overall costs and risks of climate change will be equivalent to a loss of 5% global GDP every year — Stern Review
- > Emissions can be cut through increased energy efficiency, changes in demand and the use of 'cleaner' technologies — Met Office Hadley Centre
- > The Government's new Climate Change Programme sets out its policies and priorities for action to tackle climate change in the UK and internationally; the key imperative for business over the next 10–15 years — Met Office Hadley Centre
- > Climate change provides opportunities for business. Potential economic growth for the market in the UK created by the Government's Climate Change Programme is estimated to be £30 billion — Stern Review
- > There will be numerous opportunities for small and medium sized enterprises (SMEs) across all climate change markets — Stern Review





Fit for business

As the impacts of climate change become increasingly clear, businesses are beginning to recognise this as a time of opportunity. The Met Office leads the way, with **Katie Hopkins** and her team of consultants setting the pace.

Katie Hopkins likes running — between desks at the Met Office, through the London Underground, outside in rain, hail and snow, and in international marathons. She never takes one step at a time on the stairs.

“I really like the expression, ‘fit for purpose, fit for business.’ To me, this encompasses everything from having the physical energy and the right attitude to understanding exactly what it is that customers need and want. For the Met Office, it entails taking this beautiful, brilliant science, translating it and then packaging it in a way that’s meaningful to business,” she says.

With a background in strategic consultancy, working with large FTSE 100 companies, Katie joined the Met Office in late 2006 to head up its climate change consultancy service. Her task is to take all the expertise and knowledge of the Met Office Hadley Centre and ask, “what does climate change mean for business?”

Opportune times

At this time, two major new reports on climate change are being considered — the Stern Review on the Economics of Climate Change published last October and the first instalment of the fourth assessment report from the Intergovernmental Panel on Climate

Change published in February, both of which are examined on page 6. These documents highlight the effects of climate change as well as its impacts, making Katie confident that now is the time to support businesses in investing wisely for the future.

“It’s critical for the Met Office to be responsive to the needs of large companies, which is why we’re tailoring more and more of our services to meet their specific needs. This is a time of opportunity for both the Met Office and the business world.”

Essentially, Met Office Consulting is about making sure businesses have the right information at the right time. For instance, it is no longer realistic to base the future of insurance on historical weather data stretching back 200 years. Instead, some insurance providers are now working with the Met Office to produce accurate probabilistic risk profiles, which factor in the extreme weather conditions that will become more likely as our climate changes.

“Extreme weather is a common concern for many businesses,” adds Katie. “While it is important to our customers that they understand what the climate will be like in five or ten years’ time, the extreme weather we may experience on the way and how it will affect their industry is also a big question.”

Clarity and progress

Helping people successfully plan for and profit from change is exactly what Katie finds exciting about the work of Met Office Consulting.

Born and brought up in Devon, she joined the Army and trained at Sandhurst in her early twenties, before leaving for a position in public relations and marketing. It wasn’t long before her talent was recognised and she was snapped up as the young protégé of Damian McKinney, co-founder and Chief Executive of strategic consultancy firm McKinney Rogers.



“For the Met Office, it entails taking this beautiful, brilliant science, translating it and then packaging it in a way that’s meaningful to business”

Katie spent two years following Damian around the world, quickly moving up the career ladder to work with everyone from Guinness, Smirnoff and Moët Chandon to Reuters, Thomson Financial and Barclays.

“I learnt not only to empathise but also how to challenge people with thoughts and ideas, and to reset ambitions. I learnt how to help clients get where they want in a way that is stretching yet realistic,” she says.

Beating the streets

Flitting between London and Manhattan, Katie once called Heathrow’s Terminal 4 her home. Now returning to her roots in Devon, she is also combining her Met Office career with a Masters degree in Business Administration through the Open University. She is pleased that throughout her career all her training has been hands-on.

“I am up at 6:00 a.m. to catch the train to London, where I spend on average three nights a week. I beat the streets, meeting clients, racing through the London Underground, talking on the phone — that’s what I do and that’s what I love doing.”

Despite her ebullience, Katie has no wish to be the one who does all the talking. “Met Office Consulting is about really listening to business and understanding the way it works. Only then will we suggest what insights the Met Office can offer and how we can tie this service into results.”

If Met Office Consulting can help you, please complete and return the feedback form at the back of Barometer and Katie or one of her team will be in touch.

➔ For more general information on how everyday weather and/or climate change may affect you, contact our 24-hour Customer Centre on **0870 900 0100** or email **enquiries@metoffice.gov.uk** for help and guidance.





Cleared for take-off

No one enjoys long delays at the airport, in-flight turbulence or bumpy landings — which is why the Met Office is working with the aviation industry to help make sure passengers arrive at the world's terminals safely and on time.



In recent years, the increase in low cost carriers and cheaper flights has opened up international travel to a larger number of people. The demand for long weekends abroad, annual foreign holidays and the ease of meeting global business clients face-to-face means that the number of flights is set to continue to rise by 4–5% year-on-year.

Critical to the safe operation of all flights is the weather. Ice and fog on the ground can lead to departure and arrival delays, while thunderstorms may cause diversions to a flight. Whatever the weather, the Met Office is on hand to help airlines, airports and air traffic controllers make sure your journey runs as safely and smoothly as possible.

“The Met Office is internationally renowned for its aviation meteorology – its meticulous standards of global forecasting and research provide the best guidance to some of the biggest names in aviation,” says Doug Johnson, Head of Transport at the Met Office.

De-ice not delay

Any delay on the ground is costly to airlines, increasing the pressure to plan ahead and mitigate the impacts of the weather.

In wintry conditions aircraft icing prevents take-off and is a major cause of departure delays. Ice forming on aircraft is extremely dangerous and its removal is costly both in terms of the de-icing fluid used and the potential delays in ensuring the plane is completely ice-free from the wing tips to the tailfin before it's given the all-clear to fly. Airlines are therefore keen to de-ice only when necessary.

Throughout the winter, the Met Office aircraft de-icing service provides forecasts in advance of icing hazards

such as frost, snow and freezing rain, and also takes into account the characteristics of the de-icing fluids, to warn airlines when and where de-icing will be required.

One commercial airline that relies on the service is bmi. “By improving our de-icing operations we have been able to reduce delays by a dramatic 84 per cent. The de-icing service at the Met Office ensures that planes are ready to depart – on time,” says bmi De-icing and Fuel Coordinator, Steve Crawley.

Planning ahead

Understanding the impact of the weather is important for planning safe and efficient operations all year round – not just in the winter. The Met Office provides a range of services for pilots, airlines and airports giving them all the weather information they need before any planes take-off. With leading flight briefing company, SITA, it has also developed the Advanced Weather Service which overlays airlines' detailed flight plans with forecast en route weather.

“Accuracy is of paramount importance when producing our forecasts,” says Paul Gundersen, an Aviation Meteorologist at the Met Office. “By forecasting beyond the current conditions, timely forecasts of weather hazards such as thunderstorms, snow, fog, strong winds, wind shear and icing allow pilots, airlines and airports to make decisions to ensure the safety of passengers and crew and improve operational efficiency.”

Each time you fly, you can be happy in the knowledge that the Met Office is supporting the aviation industry in every way it can to make sure you arrive at your destination safely and on time. That means all you have to worry about is whether to pack an umbrella or a bikini in your suitcase.

Met Office Aviation Services at a glance

- The Met Office is one of only two World Area Forecast Centres
- Since 1984, it has been providing global forecasts of winds and temperatures over 24,000 feet, twice a day, for all flights throughout the world
- The Met Office also helps to enhance safety for the north-east Atlantic routes forecasting the movement of volcanic ash plumes through the Volcanic Ash Advisory Centre
- All essential global aviation forecasts are sent by the Met Office via a dedicated satellite distribution system (SADIS) to the aeronautical community in more than 120 countries
- Below 24,000 feet, the Met Office provides comprehensive weather data for the UK and Europe
- It inspects and certifies the meteorological observations at more than 100 aerodromes across the UK for the Civil Aviation Authority
- It also issues hazardous weather warnings (SIGMETs) for aircraft en route and travelling through airspace above and around the UK
- The Met Office provides a suite of specialist aviation services:
 - Aircraft De-icing: major commercial airlines, such as bmi, rely on this service to ensure their planes can take-off safely and punctually in cold weather
 - Airport Briefing: an operational decision tool that helps improve efficiency, capacity and to save money
 - Airline Briefing: this new online service for 2007 helps flight operations personnel make informed and safety-critical decisions
 - Advanced Weather (with SITA): integrates the latest weather information with planned flight routes to brief commercial airline pilots
 - OpenRunway: gives airports advance warning of the need for runway de-icing and snow clearance and gritting when snow and ice are on their way.

➤ For more information on how the Met Office Aviation Services work with the aviation industry to enhance safety and reduce costs, contact the Customer Centre on **0870 900 0100** or visit www.metoffice.gov.uk





Who dunnit?

In criminal and civil investigations, detailed weather reports can provide missing clues, be used as vital evidence in court or help settle disputes over claims. All thanks to Met Office Forensic Meteorologists.

When we think of the weather we usually want to know what it's going to be like today or how it may affect us in the future. But in forensic meteorology the focus is on the past. Weather data from the scene of an unfortunate or tragic event such as a flood, road traffic accident or even a murder can help the police and legal services answer those crucial questions: What? Why? When? Where? And how?

"Forensic meteorology covers the areas of weather relating to the law. We try to help the legal system resolve civil and criminal cases whenever the weather may have had some impact," says Met Office Senior Forensic Meteorologist, Jim Buckman.

"We do that by analysing and interpreting weather from different data sources, so we can arrive at an opinion about what the weather may have been doing when the incident occurred. However, it's not our role to say who's guilty or not. In fact, sometimes we won't know any more details than the place, date and time."



Weather-proof

The detailed 'aftercasts' produced by Jim, who heads up the Met Office's England and Wales land-based operation, are used by the police, solicitors and insurers as evidence in courts or to resolve claims. On some occasions Jim or one of his colleagues, Martyn Sunter in Scotland and John Wylie in Northern Ireland, may also be asked to appear in court as an expert witness.

"Most of our reports are for road traffic accidents, when there is an implication that the road was wet or icy," explains Jim. "We also get involved with



murder inquiries. For instance, we can help determine how long a body has been lying somewhere by looking at temperatures and rainfall."

Jim responds to over 100 enquiries each month. Recently he was involved in such incidents as the death of four cyclists in a car crash in North Wales, a case of child neglect where a baby was thought to have been left outside, an investigation into the death of a dog left in a car on a hot day and an insurance claim against a construction firm for a collapsed swimming pool.

Reading the elements

While Jim and his team have their noses close to the ground, there are other forensic meteorologists at the Met Office who have their eyes to the sky. Service Manager, David Howells, routinely supplies data for air traffic accidents. "I am often asked for elements like cloud base and visibility for accidents near high ground where, for example, pilots have flown into trouble due to a gradually lowering cloud base."

David works within the Met Office Aviation Services (which you can learn more about on pages 9–10) and answers questions from the Air Accident Investigation Branch, Civil Aviation Authority, Joint Airprox Board and solicitors.

On a typical day, he may have to describe anything from surface winds at an airfield where there has been a landing accident to light levels and moon and sun times, to determine whether or not a pilot was night flying illegally or if they would have been able to see a cumulonimbus cloud in moonlight.

For over a decade, Met Office forensic meteorologists have been working behind the scenes to help piece together legal puzzles. Next time you watch, listen to or read the news, the Met Office may have played an important part in the story.

Did you know?

- > In 2005 there were around 5.5 million recorded criminal offences in England and Wales, a fall of 1 per cent on the previous year
- > The major types of criminal offences are burglary, criminal damage, drug offences, fraud and forgery, robbery, sexual offences, vehicle and other theft, and violence against a person
- > Other types of criminal offence include kidnapping, health and safety offences and dangerous driving
- > Every year there are nearly 34,000 fatal and serious accidents on Britain's roads
- > Most road traffic accidents occur in north-west England, with approximately 3,634 each year. The lowest number of road traffic accidents occurs in north-east England, with up to 1,064 each year
- > In 2005, there were 23 serious incidents involving aircraft, but no fatal accidents in the UK
- > The worst plane tragedy was on 22 August 1985 when 55 people were killed as the engine of Boeing 737 failed and burst into flames on take-off from Manchester airport
- > The UK insurance industry is the largest in Europe and the third largest in the world. It pays out £54 million per day in claims
- > The average household spends £188 per year on home building/structure insurance, £159 on home contents and £556 on motor insurance

 The Met Office provides expert meteorological advice for all branches of the legal profession, insurance companies and those involved in civil or criminal litigation. For more information contact the Customer Centre on **0870 900 0100**, or visit www.metoffice.gov.uk



Thanks to the combined efforts of over 30 countries, which have deployed around 2,800 free-drifting Argo floats in oceans around the world, scientists can now begin to answer fundamental questions about the big blue and its role in climate change.

Observations at sea

When the Ancient Greek, Jason, embarked on his quest for the Golden Fleece, he sailed away on a ship named the 'Argo'. On board was a 50-strong crew of men including the musician Orpheus, who set rhythm for the rowers, and helmsman Tiphys, an expert in the new art of navigation, which he learned from the goddess Athena.

For centuries, the legendary voyage of Jason and the Argonauts has inspired plays, films and numerous other works of art and literature. Today, however, the names 'Argo' and 'Jason' also have great standing in the ocean science community. Argo data from beneath the ocean surface complement sea-surface height measurements from the Jason satellite altimeter.

Argo at sea

Argo floats measure ocean temperature, salinity and pressure (depth). Once a float is deployed, it will sit at the surface for six hours and send test data before starting its mission. It then sinks to a parking depth of 1,000 metres, where it drifts for nine days. Next, the float descends to 2,000

metres before returning to the surface, measuring temperature and salinity at various depths as it rises. Finally, it transmits the data it has collected back to a satellite and its position is determined. The cycle is repeated on a ten-day basis until the float's batteries run out after around four years.

"Argo is groundbreaking because it gives us five times as many observations of the oceans as we had before — to greater depths and higher accuracy. Before Argo began in 2000, observations were largely limited to temperature above 500 metres depth from the main shipping lanes — we now have global temperature and salinity data to 2,000 metres depth," explains Jon Turton, UK Argo Programme Manager at the Met Office. "It's important to have both as it enables scientists to determine the density structure of the ocean, which is vital for accurate and reliable ocean model forecasts."

The output and importance of these models is explored on page 15.

The oceans and climate

The oceans can store over 1,000 times more heat than the atmosphere. Most of the heat produced by global warming goes into the oceans and so they act as a heat sink and a brake to delay climate change. Although the upper ocean has been cooling globally since 2003, over the last 50 years it has warmed and temperatures are predicted to rise in the long-term. Change and variability in the oceans is not yet well understood — for the first time Argo will allow scientists to observe variability over annual and inter-annual timescales.

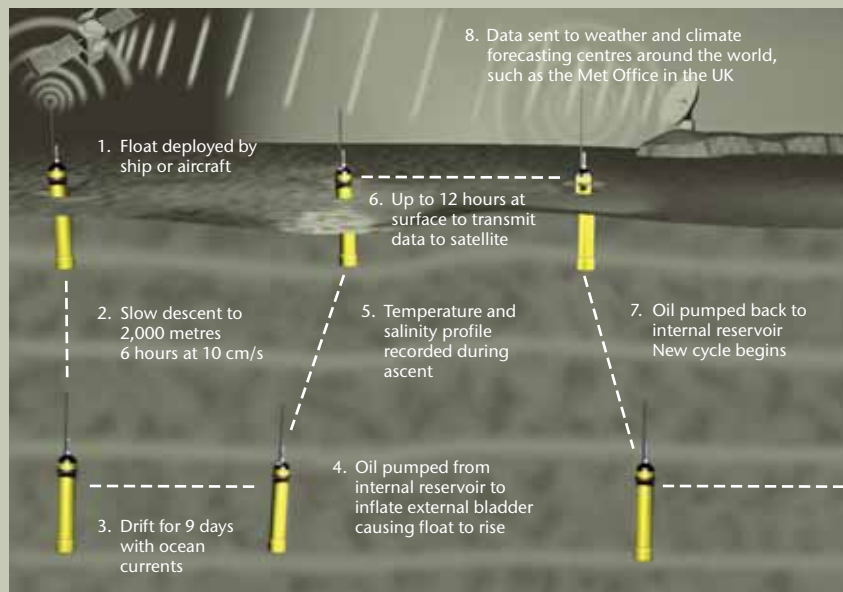
It is now well known that sea levels are rising and that Arctic ice is retreating. Sea levels have risen by 10–20 cm over the last century and the rate is accelerating. Argo data will help scientists determine the contribution to sea level rise of thermal expansion due to ocean warming or cooling.

A particular area for concern is an ocean current called the Atlantic Thermohaline Circulation, often referred to as the 'Gulf Stream'. At present, warm water comes up from

the Caribbean and Gulf of Mexico, crosses the Atlantic and travels past the UK before flowing into the Arctic Ocean, where it sinks and returns at depth to where it started from. This warm current releases heat into the atmosphere which makes our climate much warmer and wetter than it would be otherwise.

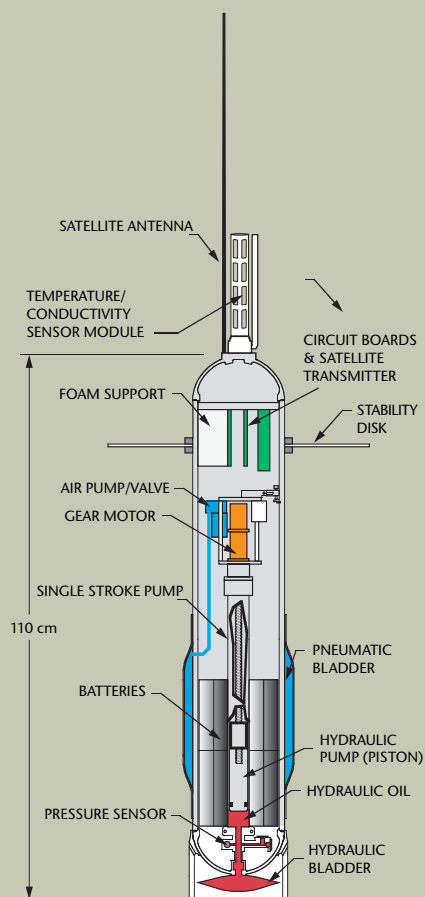
Because the Arctic ice is thawing, more fresh water (which is less dense than salty water) is being released near the surface at the Arctic end of the circulation. "The danger is that this could inhibit the overturning of the circulation, which currently keeps the European climate relatively mild in comparison to places such as Labrador in Canada — which is as far north as the UK yet much colder — and so could lead to a colder climate for western Europe," says Jon.

"Argo floats deployed in the North Atlantic will complement data from ocean moorings placed by the Natural Environment Research Council at 26°N in monitoring the thermohaline circulation to detect any changes in the Gulf Stream."



Argo fact file:

- > The first Argo floats were deployed in 2000. By mid-2007 there will be 3,000 operating which will provide 100,000 profiles annually, covering all the ice-free oceans around the world
- > Argo floats measure temperature and salinity down to 2,000 metres at 2,000 dbar pressure — that's 200 times greater than atmospheric pressure
- > Each float can operate for as long as four years and make around 150 profiles
- > Each float weighs just 25kg and is little more than one metre high
- > It costs around US \$25,000 to buy and deploy a float and collect and process the data over its lifetime
- > To maintain the 3,000 float target around 800 new ones must be launched every year — overall, some US \$20 million a year is needed to ensure that Argo continues its global odyssey
- > The oldest UK Argo float has made 175 profiles and is still going



Keeping Argo afloat

Since 2001, the Met Office has been responsible for deploying around 200 floats contributing to Argo. There are around 100 of these running at the moment and it hopes to launch 40 to 50 new floats each year. Funded by the Department for the Environment, Food and Rural Affairs and the Ministry of Defence, the Met Office works closely with the National Oceanographic Centre in Southampton, the British Oceanographic Data Centre and the UK Hydrographic Office on the UK Argo Programme.

Although it's only just at the beginning of its odyssey, Argo is already making big waves in ocean forecasting and climate change science.

➔ All data from the Argo programme is freely available — anyone can access the data from the websites of the two Global Argo Data Centres, Coriolis: www.coriolis.eu.org and the Global Ocean Data Assimilation Experiment: www.usgoda.gov





Forecasting the oceans

The world's oceans can be inhospitable places yet are the workplace of many in the oil exploration, shipping and defence industries. Adrian Hines of the National Centre for Ocean Forecasting at the Met Office explains how even the remotest oceans can be forecast to ensure the safety of all those at sea.

The sheer size of the ocean and the inaccessibility of many areas make a fully comprehensive observing network impractical. Traditionally, ships provided weather observations at the surface as well as temperature information below the surface. In recent years, the Argo programme (see pages 13–14) has dramatically increased observational coverage, although the water below 2,000 metres depth remains largely untested.

The best description of the ocean is obtained when these observations are combined with satellite measurements of the surface elevation, roughness, temperature and colour (colour providing a measure of biological content). It is only by inputting all of these data into complex ocean models that Met Office scientists can accurately forecast the remotest regions of the world's oceans.

Ocean models at the Met Office provide nowcasts and forecasts of temperature, salinity and currents (**Figure 1**) at broad-scale globally, in more detail for selected regions and at local scale for some coastal

areas. The open ocean forecast models assimilate real-time satellite and in situ observations to produce the most accurate estimate of the current ocean state.

Other models predict surface waves for the global ocean, with high resolution detail around the UK. Near-shore wave models, specifically designed to represent processes in shallow water, are nested into these offshore wave models and, in turn, used to drive downstream models that can be applied to support amphibious military operations anywhere in the world.

As reported in Barometer issue 5, the Met Office has the capacity to rapidly relocate its ocean and wave forecast models to any area of the world of interest to the Royal Navy. Work to understand the world's oceans draws from the considerable expertise of the National Centre for Ocean Forecasting (NCOF) described on page 16, based at the Met Office, Exeter.

The Met Office Marine Business group in Aberdeen works with commercial customers such as the offshore and energy industries to help them make full use of these ocean forecasts. Flow through gas pipelines across the bed of the North Sea, for example, is critically dependent upon the temperature along the pipeline which the Met Office can predict (**Figure 2**).

Outputs from the models can also be used in the design and construction of offshore oil rigs and to support oil exploration at sea with essential surface wave information. The path of drifting objects, such as oil spills or even the flotilla of plastic bath toys lost at sea in 1992 (page 2), can also be predicted. Just like Dr Ebbesmeyer who is tracking the toys' journey, the Met Office could use its complex ocean models to estimate the likelihood of one of the 29,000 plastic frogs, beavers, turtles or classic yellow ducks washing up on a beach near you.

High-resolution surface temperature data and information from these models will be used in the

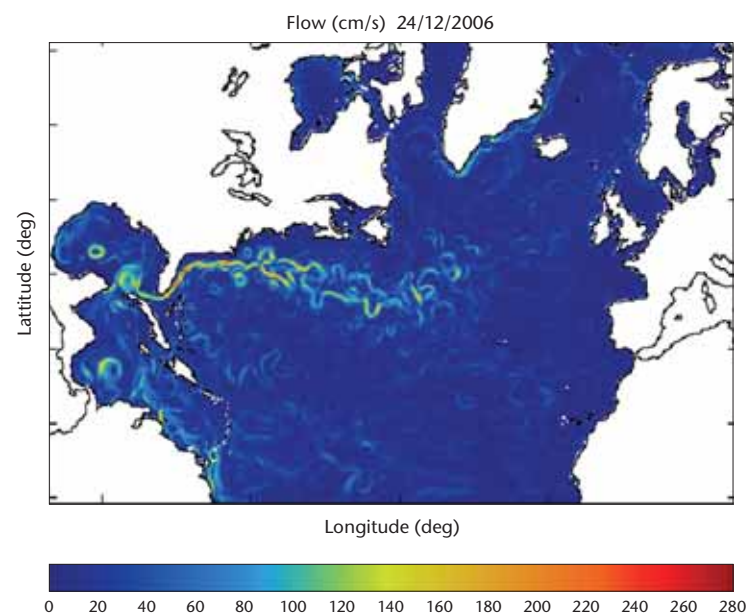


Figure 1: An example of ocean surface currents



future in Numerical Weather Prediction models to improve forecasts of everyday hazards such as offshore and coastal fog, helping sailors make the most of their leisure time and shipping companies plan the safe passage of perishable cargo. The aviation industry too needs high resolution maps of sea-surface temperature to identify warm water areas that may trigger cumulonimbus activity — a real danger to all aircraft.

Initiatives are underway to coordinate ocean modelling activities internationally so that in situ and satellite observations can be shared and coverage further improved. This system will form the European Commission's Marine Core Service, a major contributor to the Global Monitoring for Environment and Security programme jointly run by the European Commission and the European Space Agency. With it, the most inhospitable regions of ocean can be forecast with even more accuracy, making them safer to work in.

Temperature (°C) at 9999m on: 16/12/2006

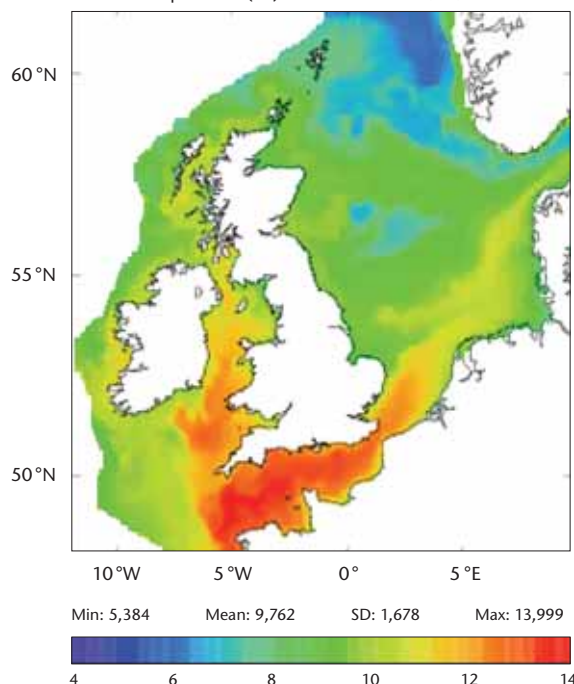


Figure 2: Sea-bed temperature prediction



Science profile

→ Mike Bell, Head of Ocean Forecasting

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

As Head of Ocean Forecasting, Research and Development, Mike Bell is responsible for developing short-range ocean forecasts that include elements such as surface waves, temperatures within the oceans and the flow of currents. He is also Head of the National Centre for Ocean Forecasting (NCOF) and works with other leading scientists to pull-through research funded by the Natural Environment Research Council into the Met Office's operational forecasts. Data from these forecasts are made available to a wide range of different agencies and the general public.

The feature opposite provides some insight into why forecasting the oceans is important. "Short range surface wave and current forecasts are crucial to the safety of shipping, naval and maritime operations and oil and gas platforms, for instance. They also impact on search and rescue operations," explains Mike. "Meanwhile, data on the temperatures in the oceans inform our seasonal forecasting — they can help meteorologists to predict up to nine months in advance whether there is likely to be a cold winter ahead."

Part of the team

Including the Met Office, NCOF has five member organisations (see 'Who's who in ocean forecasting?' opposite). "In particular, we focus on enhancing the ocean models so we can give more reliable and accurate predictions for numerous applications such as services for defence.

Our work also supports climate change prediction because we use the same models and can test their skill in short-range forecasts," explains Mike.

Liaising with experts at POL, NOCS, PML and ESSC, along with his team of 20 scientists at the Met Office, Mike finds his role both challenging and enjoyable.

"Typically, I spend most of my time talking. You can have two scientists coming together from different fields and when it all clicks, that's where the best progress is made."

Everything flows

Mike made a seamless transition from his studies of Physics and Philosophy and then Maths at Oxbridge into his first job at the Met Office's Geophysical Fluid Dynamics Laboratory in 1983. It was during this time that Mike gained the theoretical knowledge and background that would prove invaluable when he later moved into ocean data assimilation and modelling.

While his focus is more on the people behind the science these days, rather than doing the science himself, Mike nevertheless retains his passion for gaining an understanding of how the oceans work.

"Some ocean processes are not intuitive. What actually happens is not what you might necessarily expect. It's an exciting challenge to try to understand the processes going on in the ocean models and to improve them," enthuses Mike.

Who's who in ocean forecasting?

The National Centre for Ocean Forecasting is made up of five member organisations. As well as the Met Office, they are:

- the Proudman Oceanographic Laboratory (POL), specialists in measuring and modelling shelf seas
- the National Oceanographic Centre in Southampton (NOCS), which observes and models the deep oceans
- the Plymouth Marine Laboratory (PML), concerned with ecosystems, including ocean phytoplankton and nutrients levels
- the Environmental Systems Science Centre (ESSC) at the University of Reading, which develops data assimilation and web server technologies



What impacts will climate change have on society? Will it increase the environmental stresses already felt in vulnerable parts of the world? **Dr Debbie Hemming**, of the Met Office Hadley Centre, examines these key questions for the future.

Climate change: a global stress

The rapid climate changes projected for the 21st century have the potential to seriously threaten environments, societies and economies. Due to their greater vulnerability, developing countries are likely to experience the most rapid and severe impacts of climate change. Although developed countries may have some ability to adapt to the direct impacts of climate change, major stresses may also arise from indirect impacts such as changes in international trade or increases in global insecurity — issues that would not be directly manageable.

The amount of environmental stress caused by our changing climate and the consequent responses of individuals and governments are dependent on the relationship between these changes and socio-economic factors; in particular population and economic growth. In general, high

population growth increases the impacts and stresses of climate change because of resource shortages and higher population densities, whereas high economic wealth reduces the vulnerability of societies to climate by increasing their capacity to adapt.

Future climate change is likely to significantly alter the availability and distribution of many of the resources that are vital for life, such as water and food, and disrupt key socio-economic activities including energy supply, international trade and urbanisation. Unfortunately, many of the regions that are projected to experience the largest climate changes, such as south-east Asia, sub-Saharan Africa and the Mediterranean coast, are already vulnerable to environmental stress from resource shortages, rapid urbanisation, population rise and industrial development.

In regions where the combined impacts of climate change place acute stresses on human activities, socio-economic instability may result in population migrations and conflicts between neighbouring populations. While some of the impacts of climate change may be beneficial to human systems, such as the expansion of productive agricultural land into northern regions that are currently too cold, or reduced human mortality in the winter due to warmer temperatures, most of the impacts are likely to create or enhance stresses on environments and populations. These include rising sea levels particularly in Bangladesh, India and the Gulf of Mexico, reduced crop yields in Africa as a result of decreasing precipitation and frequent droughts, and increased numbers of people at risk from malaria in Africa.

Water is one of the most important natural resources which is likely to change significantly in our future climate. Changes in the volume, spatial distribution and timing of the supply of water can all significantly alter regional environmental stresses. According to the United Nations Environment Programme, in the mid-1990s about 1.7 billion people (one third of the global population) lived in water-

stressed countries and 20% of these lacked access to safe drinking water. By 2030, assuming a 'business as usual' scenario, population and economic growth alone are estimated to nearly double this number and in many regions climate changes are likely to exacerbate these stresses. Global warming is expected to increase evaporation and intensify the water cycle, and this is likely to increase precipitation in some areas, decrease it in others and generally lead to more intense precipitation events.

Recent results from the Met Office's 244-member ensemble of global climate model runs indicate that many of the regions of existing water stress, for example, the Mediterranean, parts of the Near East, north-west Asia, north-east Africa, southern Africa and western Australia, may experience decreases in precipitation of at least 20% by about 2050. Large reductions in river flow are projected across southern Europe, the Middle East, the Amazon Basin, and the Danube. As over half of the world's drinking water is extracted directly from rivers or reservoirs, these changes could significantly exacerbate water stress in affected regions and, where rivers flow across borders, generate a potential source of international conflict.





Ashley Jackson

Stormy weather?

That's the best kind

Ashley Jackson has been a professional water-colourist for 44 years and is now one of Britain's most respected artists. He has published several books and also made numerous TV appearances including his own show, 'A Brush with Ashley'. Here, he tells us why wild, wet weather conditions are both his theme and his muse.



Ashley, whose father was in the British Intelligence, was born in Penang, Malaysia and moved to Huddersfield aged nine. It was then, while gazing out over the Colne Valley that his lifelong love affair with the Yorkshire landscape began. It's a love affair based, not on perfect blue skies and rolling hills, but on the drama and intensity of ever-changing scenery.

"I always work outdoors and love the wild weather of the Pennines", says Ashley. "People sometimes ask 'why not Cornwall?' but it's too manicured for me. I like wild environments."

The Pennines' gruff beauty and brooding weather go hand-in-hand. From wind and rain to snow and frost, the elements are as changeable as they are forceful. As Ashley puts it, "You've got to wait until the sky's right then get out there, quick. If you miss it, start again with whatever comes next, but it should always feel natural and never like hard work."

Rain man

Despite his south-east Asian roots and having painted across continents, Ashley remains infatuated with the Pennines' subtle colour palette, "Wherever I go, I can't wait to get back here. The moors can start off burnt sienna and immediately after the rain they're a rich burnt umber."

But it isn't just wild weather that inspires Ashley. In fact, the wind and rain could be described as almost a symptom of his real ambition, "I chase light. The Pennines' saucerpan skies, where the light comes from the horizon instead of above, are magical. Once the

birds start flying low you know there's a storm coming so you look for the break in the sky — the window — and use that as your white space. Then the rain comes down in curtains and, if I'm lucky, creates my favourite scene — where the sky and the earth blend into one."

Keeping warm is the easy bit and Ashley maintains that all you need are dry feet, a warm hat and a compass. Whisky is also useful — Ashley adds a few drops to his water pail, creating an instant anti-freeze for his brushes and paper.

In his element

With Ashley there's no preparation, no shortcuts, not even an easel — just spontaneity. He also paints vertically, as opposed to the usual 45 degree angle — a skill he mastered as an apprentice glass guildler. And when the weather is particularly fierce he paints behind dry stone walls for shelter.

Such raw conditions would have most people heading for home, or a nice,

warm studio. But Ashley thrives on the Pennines' elemental force, and his home studio is small and simple — his real 'studio' is the Pennines themselves.

On the horizon

Known as 'the people's artist', Ashley's down-to-earth attitude to art as well as his talent is appreciated the world over. It's even made him popular with royalty. He often paints at Highgrove with Prince Charles and regularly gets involved with fundraising and 'live art' sessions for the Prince's Trust. But is a talent like Ashley's possible to teach?

"You can teach people the mechanics of watercolours but to produce a truly good painting, an artist needs soul. Soul is what turns a picture into a painting. Too much art today is clinical and dehumanised. Good art should make people want to touch it."

The ultimate in cool

Starting with water and ultimately returning to water, ice sculptures use ice as a raw material and represent clarity, simplicity and precision.

The structures are mostly ornamental and differ each time people view them. Melting is all part of the charm of an ice sculpture as it changes over time.

Sculpting ice is difficult due to the variability and volatility of the material. Suitable ice is carefully selected — the ideal material is made from pure, clean water that makes dense, highly transparent artworks with no air bubbles.

Working with ice is also hazardous. Ice is heavy but brittle and slides around, while the tools used are very sharp. Ice is sawed, chipped and brushed away like wood or stone. Often, ice sculptures must be completed quickly to avoid melting so sculptors are most happy in the spring and autumn when they can work outside in ideal temperatures.

