Safe keeping

Protect your world with our climate science and services
Forecasting today and for tomorrow

Climate change is an urgent global issue that has already begun to impact upon every nation, influencing the way we live and threaten our very survival.

Climate change is a natural phenomenon, but humankind has drastically altered the process so that, today, our changing climate threatens us more than any other global event. It’s now clear that the emission of greenhouse gases from human activities, such as burning fossil fuels, deforestation and inappropriate changes to land use, is causing climate change. Across the world its effects are being felt environmentally, economically and socially.

Even if concentrations of greenhouse gases and aerosols were stabilised at year 2000 levels we would still expect temperatures to reach 1.4 °C above pre-industrial levels by 2100. But beyond that level of climate change there is a choice and it’s critical for humankind that we all make the right one.

Climate change affects the type of food we grow and eat, and the availability of the water we drink. Wherever we live, rising temperatures, changing rainfall patterns and more extreme weather events are likely to further influence our health and well-being. A particular concern is that those least responsible for climate change, in the least industrialised countries, are already feeling the worst effects.

Around the world, businesses are beginning to factor climate change into their investment decisions and act with corporate responsibility. Governments, meanwhile, are considering the long-term effects on migration, infrastructure and security. This concerted effort will help us adapt to the climate change we’re already committed to, but we must also act to slow down the rate of future change.

In many countries, action on climate change sees governments putting in place mitigation policies to reduce emissions. In July 2009, the UK Government pledged to deliver emissions cuts of 18% on 2008 levels by 2020. Achieving this target includes channelling around £3.2 billion to help households become more energy efficient; making the UK a centre of green industry; and sourcing 10% of UK transport energy from sustainable sources.

While governments also negotiate international agreements on reducing harmful emissions, we must all look for more sustainable ways of life and do our bit for the environment by making the right choices as individuals.
Growing food

While economics and politics affect food production and distribution, climate change also exerts significant and complex influences. By 2050 it’s estimated that there will be nine-billion people to feed across the world.

Food security is defined by the United Nations as the state when everyone in the world has access to the food they need for their health and well-being. But how do we feed nine-billion people in 2050? This is the question asked by the Food and Farming Futures project, an initiative led by the Department of Business, Innovation and Skills and overseen by Professor Sir John Beddington, the Government’s Chief Scientific Adviser. In particular, the project looks at how this many people can be fed healthily and sustainably in the context of a changing climate. The studies form part of the Foresight Programme which provides scientifically-assessed visions of the future to inform Government policy. A report on food and farming in oceans and freshwater environments as well as on the land is due in 2010 and involves the Met Office working in partnership with the Walker Institute to provide key scientific data on the effects of climate change.

LIVES AND LIVELIHOODS

The climate affects the kind of crops that can be grown so, as it becomes warmer and in many cases wetter or drier, there will be winners and losers. Some areas will be able to grow new crops as the climate becomes more favourable, but in many cases the traditional crops will fare worse.

“Flooding can wipe out crops in one day,” says Richard Betts, Head of Climate Impacts at the Met Office. “Drought can have very serious impacts. Farmers are very aware of the climate they’re working in and, up until recently, have known roughly how often to expect extremes of weather. As the climate changes, some extreme weather will occur more frequently putting lives and livelihoods increasingly at risk.”

A warmer climate can also encourage diseases such as Bluetongue to take hold in the UK. Carried by midges borne on the wind, Bluetongue virus infects sheep and cows with devastating financial consequences for farmers. With climate change it is moving further north. The Met Office has developed an early warning system for the UK which allowed the UK Government to implement a targeted vaccination programme that kept the country free of Bluetongue in 2008, despite more than 20,000 cases being reported in France and as far north as Norway.

THE BIG PICTURE

“We need to consider all aspects of global change, not just the climate,” explains Richard. “Pollution from our modern way of life also affects plant growth through increased levels of carbon dioxide (CO2), diffuse radiation and surface ozone. This has positive and negative effects.”

Far northerly and southerly latitudes are experiencing improved crop production because of warmer temperatures and more CO2 in the atmosphere, both of which help plants to grow. At the same time, however, weeds are becoming more prevalent. Direct radiation from the Sun means that some parts of a plant are in sunshine, while others are in shade. Pollution hazes of soot, dust and sulphur dioxide cause diffuse radiation which helps sunshine to reach all parts of a plant and encourage growth. Conversely, increasing ozone near the Earth’s surface leads to significant reductions in regional plant production and crop yields. Surface ozone damages plants, affecting their ability to soak up CO2 from the atmosphere and accelerates climate change.

Using climate model projections for the next 20 to 50 years, the Met Office and its partners are studying the effects and interactions of climate change on food production and security. “There are huge challenges facing food and farming due to a growing world population and limited resources, such as water and land,” concludes Richard. “Intricately-linked to this is the issue of climate change and concerns over the environmental impacts of agriculture. By looking at the bigger picture, the Met Office is helping policy- and decision-makers both in the UK and overseas to develop strategies to manage our future.”

In Russia, melting permafrost will provide more land for food crops to be grown, but much of the terrain is forest and its destruction will have a dramatic effect on the world’s carbon store (see pages 20 & 21). Funded by the Foreign and Commonwealth Office, the Met Office is taking part in a project with Roshydromet, Russia’s Federal Service for Hydrometeorology and Environmental Monitoring, to examine the effects of a warmer climate in northern Russia and the potential for agricultural expansion without causing further climate change.
Supplying water

Around the world, severe impacts of climate change are expected on the supply of water. Predicted changes in seasonal rainfall and extreme weather events, including strong downpours, also bring the increased risk of flooding and drought.

THE NILE PROJECT
The Nile is the longest river in the world. It flows through eight different countries and a range of climates, experiencing both tropical downpours and intense evaporation. The Nile is a crucial resource for the economy of east and north-east Africa. The supply of water for drinking and agriculture, the production of hydro-electric power and the lives and livelihoods of millions of people depend on the river.

In order to assess the impacts of climate change on river flow in the Nile, UNESCO and the United Nations Environment Programme have funded an ongoing project. In particular, it is looking at inflow to the High Aswan Dam which helps to control water reserves and minimise incidents of drought and famine.

The Met Office has been working with two partners on the project – the Nile Forecasting Centre, part of Egypt’s Ministry of Water Resources and Irrigation (MWRI) and the Danish Hydrological Institute (DHI) which is an independent, international consulting and research organisation.

WATER FOR FUTURE GENERATIONS
The key question is: How much water will flow in the River Nile in 30 to 50 years’ time? Increasing temperatures, evaporation rates and snow melt will all affect water availability and run-off from the River Nile.

The Met Office is using a regional climate model called PRECIS – or Providing Regional Climates for Impacts Studies, to give it its full title – to ascertain changes in the water balance of the Nile Basin out to 2050.

Five different versions of the global climate model, chosen for their ability to reproduce important features of the present day climate, are driving five PRECIS simulations over the region. This technique, developed by the Met Office, creates an ensemble of projections made by running slightly different versions of the same model. Each model version has a different, plausible set of parameters describing processes such as thunderstorms or turbulence that, because of their nature, cannot be explicitly resolved by computer models. This approach will help to assess future climate change by estimating prediction uncertainty.

The output from these simulations is being used to generate climate change factors that DHI will use in the Nile Forecasting System, the hydrological model used by MWRI in Cairo. This specialist advice can then be used by the MWRI to plan for the challenges of a changing climate.

The Egyptian partners have also been trained in using PRECIS, which can run on most computers. The software is provided free to some qualifying countries and is now ready to be extended to projects in other parts of the world such as Asia, South America and Africa.

“…the lives and livelihoods of so many people depend on future local water resources. This innovative project – and others like it – involving the Met Office help to ensure that countries can adapt and ensure sufficient water supplies in a changing climate.”

Helen Bye, Senior Business Manager, Met Office

Around 98% of Egypt’s water comes from the Nile.
Building cities

The capacity of concrete and other materials to retain heat, along with waste heat from buildings and traffic result in urban heat islands, which have long been known to modify their local environment.

Planners and local governments need to be able to predict the impacts of rising temperatures in cities due to climate change and the urban heat island effect. The Met Office is exploring the impact of urban energy use in a changing climate and including cities in its climate models. Mark McCarthy, Climate Research Scientist, explains:

Q: What are urban heat islands?
A: Towns and cities tend to be measurably warmer than neighbouring rural areas, particularly at night. Buildings, roads, pavements and other structures retain heat from the Sun during the day and release it slowly at night-time. Cities receive additional heat as a by-product of electricity and gas used in buildings, traffic, and even directly from human bodies. Air-conditioning systems, for example, cool buildings, but expel warm air into the local atmosphere.

We refer to urban heat "islands" to reflect the fact that even the largest cities occupy a small fraction of the available land-surface. Urban areas can also modify other aspects of local weather and climate such as reducing wind speed, increasing cloud cover and changing rainfall patterns both within and downwind of the city.

Q: How do urban heat islands affect human beings?
A: Currently, about half of the world’s population live in urban or suburban areas. By 2050 it will be closer to two-thirds. Therefore, it is vital that we understand the potential impacts of these urban climate effects on people.

During the summer, higher night-time temperatures lead to nocturnal heat-stress and disrupted sleep for city residents, posing a bigger health risk during heatwaves. The demand for air-conditioning and therefore energy use is higher during the summer and it becomes harder to keep transport systems comfortable (e.g. underground rail networks).

During the day, roads, walls and roofs exposed to the Sun can become very hot, resulting in even greater discomfort. Conversely, for cities in cooler climates the urban heat island effect can reduce cold-stress in winter and associated energy demand for heating.

Q: What research has the Met Office been doing into urban heat islands?
A: Met Office scientists have, for the first time, incorporated an urban model within our climate model to compare the urban climate of 1971–1990 to that predicted for 2041–2060 resulting from changes in climate and urban energy use. The findings will ultimately inform governments and others of the potential urban vulnerabilities both now and in the future.

A major project we’re working on is called CIRCE and funded under the European Commission’s Sixth Framework Programme. It aims to highlight the impacts of climate change and possible adaptation measures in urban areas. Athens (Greece), Beirut (Lebanon) and Alexandria (Egypt) are currently being studied in detail with respect to the problems that may arise from climate change.

Q: What can be done to lessen the urban heat island effect as the climate warms up?
A: The severity of an urban heat island is related to the amount of space it covers, whether or not it is low-lying or dispersed, and the amount of green space and open water. To some extent, adaptation options for urban heat islands can be seen by looking at the design of cities that exist within different climates. Many cities located in hot climates are characterised by light-coloured roofs and buildings which reflect sunlight, and tall, narrow streets to keep people shaded at ground level. Buildings often have external shutters on windows to keep the Sun out during the day. Conversely, in cooler climates much of the built environment is focused on retaining heat during the winter.

Reducing the energy requirement of cities for heating, cooling and transport with appropriate adaptation measures would both reduce the urban heat island effect and greenhouse gas emissions, helping to minimise some of the worst impacts of climate change.
Planning security

Climate change will not only affect the way we live, but will bring serious issues for politicians, the military and humanitarian organisations.

Human necessities including food, water and energy may become national security issues. Projections of climate change can be used to identify regions where these issues may be most likely. Here, we look at how the Met Office can help the UK prepare for changes to the political map.

WHAT IS CLIMATE SECURITY?
Climate change will affect all of the world’s peoples and economies, with significant political implications that could affect global security. Under a changing climate, relationships between all nations will be affected through changing economic dynamics, human migration, humanitarian crises and changing access to resources such as food and water. Developed and developing nations alike will be affected and the impacts of changes in climate will stretch the coping capacities of some countries beyond their current limits.

Some of the most likely impacts of climate change include changes in rainfall which in some areas will lead to reductions in drinking water, irrigation for crops, and water supply for dams that generate hydro-electric power. In other areas, changing weather patterns will lead to flooding and crop damage. Higher temperatures will lead to the increased risk of drought, desertification, heatwaves and higher demands on energy for air-conditioning. Sea-level rise will lead to flooding of low-level land and increase the impact of storm surges.

Where these impacts affect the coping mechanisms of people there is a potential for internal unrest, conflict and humanitarian disasters. Although climate change alone is unlikely to be a cause of conflict, it will multiply the threat, particularly in nations that are already vulnerable to conflict.

Whilst the impact of climate change will be worldwide, the most severe impact is likely to be felt in developing nations. Here, life is already incredibly challenging and the impact of climate change may tip the balance from subsistence living to a survival situation. This could pose a huge humanitarian problem both within countries and the surrounding regions. For example, displacement of people from their homes due to climate impacts may lead to internal tension and has the potential to raise tensions across regions.

Knowledge of the type and range of likely changes to the climate gives nations time to plan to meet the challenges they will bring. Adaptation strategies may involve developing new trading patterns, updating trade agreements and finding additional resources. Advance warning of the expected impacts could help countries to find political solutions to climate change scenarios before unstable situations escalate into conflict.

HOW CAN THE MET OFFICE HELP CLIMATE SECURITY?
The Met Office is actively researching the impacts of climate change globally. This information is being used alongside measures of vulnerability to identify those nations most at risk. The Met Office is working across the UK Government and military to use this information to better prepare for future crises so that potential humanitarian disasters can be anticipated and subsequently avoided or alleviated. Those areas identified as potential conflict zones are being used to influence long-term military planning and procurement.

Key trigger points for security issues will include loss of resources or changes in availability. Water supplies are essential for providing clean drinking water and are closely linked to food availability. In many regions, water resources are shared between neighbouring countries and are already scarce. Rainfall is also critical to generating power supplies from hydro-electric schemes. Changing rainfall patterns may cause regional tensions over water supply and use.

“Water supplies are perhaps the most critical aspect of climate change for many countries and, by modelling climate change, the Met Office is able to identify where we might expect changes in water availability,” says Kirsty Lewis, Principal Climate Change Consultant.

Another area where climate change could potentially affect international relations is the Arctic. Explains Kirsty, “As Arctic sea-ice melts, new trading routes are likely to open up; there will be greater access to mineral resources and changes in fishing patterns. This means that countries will need to agree on how the rights to these benefits should be shared. Although this will not necessarily lead to conflict, the UK may be required to operate in the area so will need to plan for this.”

Climate security is not just a national issue, but will affect the global political and humanitarian map. Climate data can be used to help all nations plan for these implications and the Met Office has the expertise and services to guide them.

*Modelling the climate provides information that can inform decision-making and will assist governments in adapting to a changing climate. Kirsty Lewis, Principal Climate Change Consultant, Met Office*
Sourcing energy

Climate change is predicted to alter the demand for energy, the efficiency of its generation, the resilience of networks and the lifecycle of infrastructure.

With the UK Government’s pledges on emissions cuts exerting further pressure on energy companies, Rob Harrison, Principal Consultant, describes how the Met Office joined forces with the UK energy industry to study the impacts of climate change.

Q: Who commissioned the work and why?
A: In 2006, the Met Office and three leading energy companies launched a pioneering scoping study into climate change and its potential impacts on the UK energy industry. The study was the first nationwide attempt to identify how climate change will affect energy generation, distribution, transmission and demand. As well as indicating how climate change could impact the industry over the next century, it identified areas where further research was required. Following the scoping study, an industry-funded project – known as ‘Energy Phase 2’ or ‘EP2’ for short – was set up, involving 11 UK energy companies, to focus on the priorities identified by the earlier study.

Q: How will climate change impact the energy industry?
A: Global temperatures are rising, which causes regional changes in seasonal temperatures, rainfall and wind patterns, and more severe weather. These will inevitably influence how much central heating people use in winter and the need for air-conditioning in summer. It will also alter the efficiency of electricity generation, increase the flood risk in some areas and affect the way we develop renewable energies.

Q: What did EP2 find?
A: When it comes to generating power, our research showed that in hotter temperatures some power stations will be less efficient; while others situated on the coast will need to account for rising sea levels in their plans. It also confirmed that historical climatologies are no longer valid because the climate is not stationary. New climatologies that take account of climate change are already being used by many industries and increasing demand for climate science and services from the Met Office.

Q: Are the effects just limited to generating power?
A: No. Towers, cables, poles, conductors, insulators and transformers are all involved in transporting energy to our homes and businesses, and can be vulnerable to damage from wind, heat, flooding and lightning which are predicted to increase as the climate changes. For example, outside the UK’s cities cables hung between poles expand and sag in high temperatures. This means that cable ‘de-rating’ – reducing energy flow through cables to lower their temperature – will be needed more frequently as our climate changes to keep them a safe distance from the ground. In urban areas, there isn’t enough room to do this, so cables are buried deep underground. Soil modelling by the Met Office suggests that de-rating will also be required here, as the soil in many areas will become warmer and drier decreasing its natural cooling effect. Studies of the ‘urban heat island’ effect also highlight a need for more robust surface infrastructure, as the higher temperatures in cities put a strain on people, buildings and materials.

Q: How will demand and supply change in future?
A: Climate change will undoubtedly affect when and why we use energy. Traditionally, UK winters have prompted the highest demand. But with more people using air-conditioning and refrigeration in hotter summers, particularly in cities, long-established patterns of demand will change. In future, your cup of tea may taste the same, but with regional changes in temperature and precipitation, wind and wave activity, floods and storms, the energy you use to boil the kettle will have a very different history. Using climate change information from the Met Office, the energy industry is taking measures to reduce repair costs, plan investment, explore the potential of renewable energies and cut emissions while continuing to meet our energy demands.

Q: How will climate change affect energy transmission?
A: As well as the changes already mentioned, there are other potential impacts on energy transmission. For example, in regions where cable networks are to be installed underground, soil modelling by the Met Office suggests that climate change could mean that de-rating will also be required. Similarly, studies of the ‘urban heat island’ effect also highlight a need for more robust surface infrastructure, as the higher temperatures in cities put a strain on people, buildings and materials.
Staying healthy

Climate change is already having an impact on the health of people around the world.

Throughout the 21st century, rising temperatures, changing rainfall patterns and more extreme weather events are likely to further influence the longevity and quality of our lives and well-being, wherever we live. Climate change will influence nearly every aspect of our lives, from the type of food that we grow and eat to the availability of the water we drink. From the way we modify our homes to keep them cool to deciding where to build new accommodation to house climate refugees. Cross-cutting all of these themes, linking climate change with food, water, sanitation, shelter and migration, is health.

HEALTH AROUND THE WORLD

Today, one-billion people go hungry every day and over one-and-a-half-billion still do not have access to clean drinking water. It is these individuals who will suffer the most from the negative consequences of climate change, despite having contributed little to the position our world is now in. It is the economically deprived, alongside the young and elderly, in both developed and developing nations, whose health will be most severely impacted by climate change. However, we all will be affected.

The human body itself can adapt to different climates but will struggle if the changes we experience are too rapid. The direct effects of rising temperatures could mean we see a higher incidence of heatstroke, cardiovascular and respiratory diseases. This will be a particular problem in mid- to high-latitude countries, unused to dealing with prolonged periods of high temperatures (see the ‘European heatwave of 2003’ box) and also in urban areas.

Cities are often warmer than the surrounding countryside due to the ‘urban heat island’ effect (see pages 6 & 7). Any increases in temperatures in these areas could exacerbate health issues related to heat stress, with further problems where air quality is already compromised by pollution.

Additional health problems associated with climate change could include increases in mental health issues as we experience more extreme weather events (for example: stress following flooding and hurricanes); more incidences of food poisoning and water contamination as rising temperatures promote the growth, spread and survival of bacteria; increases in the number of asthma cases and other respiratory problems as plant growing seasons extend and pollution increases; and more injuries and deaths as a result of severe weather events.

“Health spans all the different impacts of climate change and affects everyone personally. The human dimension means more to people because at the bottom line it means ‘Will I survive?’”

Felicity Liggins, Climate Consultant, Met Office

Importantly for future infrastructure and resource planning, migration from areas suffering severe climate stress could put local and national health services of the receiving regions under critical pressure unless adequate provisions are made.

Malaria, one of the world’s biggest killers, will change in geographical range and transmission season as temperatures and rainfall patterns change. Climate models from the Met Office can help organisations understand how some regions, currently free of the disease, may see more outbreaks in the future, while other areas projected to see decreases in rainfall totals could experience fewer cases as breeding grounds for malaria-bearing mosquitoes dry up. Other diseases carried by insects, such as dengue fever, tick-borne encephalitis and Lyme’s disease could be similarly affected by climate change.

COULD THERE BE HEALTH BENEFITS?

Climate policy could also have beneficial effects on health. Use of greener transport methods could lead to less air pollution. Reductions in obesity and mental health problems and improved bone and heart health may follow drives to reduce our carbon footprint as more people walk and cycle.

THE HEALTH PRACTITIONER’S GUIDE TO CLIMATE CHANGE

In 2009, the Met Office contributed to the Earthscan publication ‘The Health Practitioner’s Guide to Climate Change’. This book sets out clearly the links between health and climate change, and shows how health practitioners from all sectors and all countries can take influential and practical action to prevent future negative impacts as a result of a changing climate.
Managing business

Climate change poses a significant risk to the future development of many nations.

The 2007 Fourth Assessment Report from the Intergovernmental Panel on Climate Change identified Africa as “one of the most vulnerable continents to climate change and climate variability.” The Met Office is working with Barclays to address the management of climate risk in Africa.

Barclays has a major presence across the continent, including in the key regional economies of Ghana, Kenya and South Africa. The aim of the Barclays-Met Office collaboration is to assess the economic and social impacts of a changing climate. It was officially announced by Barclays Chairman Marcus Agius at a session of the World Economic Forum, Cape Town, South Africa on 11 June 2009.

Forward-thinking organisations are developing a deeper understanding of the economic and financial risks associated with the weather, climate variability and climate change. Many turn to Met Office science and services for help in accurately identifying these risks so they can be managed and mitigated more effectively.

As part of the Barclays-Met Office project, scientific literature discussing the likely effects of climate change on key sectors including water, health and energy in Ghana, Kenya and South Africa has already been reviewed. The assessment found that all three countries are projected to suffer adverse impacts as a result of climate change, posing a serious threat to the lives and well-being of their growing populations. But where the risks are managed, there may also be new opportunities for development. This work is feeding into a more detailed analysis for Barclays and its customers, as well as decision- and policy-makers in business and government in Ghana, Kenya and South Africa. The ultimate aim is to provide them with the knowledge and tools needed to continue identifying and managing key climate-related risks in these countries, when the project comes to an end.

“Adaptation is about building resilient communities so people can not only sustain changes in climate but thrive in spite of them.”
Matt Huddleston, Principal Consultant, Met Office
Every form of transport is affected by both short- and long-term changes in the weather and climate.

"The aviation industry has to look many years ahead in its planning, and the changes in climate taking place show that historical data are no longer relevant for strategic planning."

Kirsty Lewis, Principal Climate Change Consultant, Met Office

HIGHWAYS AGENCY

Building, operating and maintaining roads is a high-cost investment that is vital to any nation’s infrastructure for trade, travel and tourism. The Met Office works closely with the Highways Agency, which is responsible for operating, maintaining and improving the road network in England, to minimise the effects of the weather and keep traffic flowing every day.

Anticipating future weather patterns is also essential to planning and building roads that will meet the demands of the future. Climate change will affect the initial design and construction of motorways as a long-term project but, in the shorter term, the cost of maintaining and operating these major roads will also be changed.

Some of the most likely impacts of climate change include hotter temperatures, changing rainfall patterns and more extreme weather events such as high winds, storms, floods and heatwaves. Despite the warming trend, cold snaps will still occur, though less frequently than today.

Recognising the need to prepare for changes in today’s weather and tomorrow’s climate, a series of workshops were arranged that brought together experts from across the transport industry and the Met Office to devise a strategy to adapt to climate change. A hotter climate may cause road surfaces to melt, particularly in a heatwave. Warmer year-round temperatures will also increase the cost of removing roadside foliage. More rain could mean greater flooding on the roads. While an occasional cold snap will lead to demands for gritting the roads and higher costs.

"It is relatively cheap to incorporate features, like bigger drains to mitigate flooding and alternative road surfaces that will not melt in hot conditions, at construction stage," says Rob Harrison, Principal Consultant. "But it is expensive and inconvenient to change them once the road is built.

“That's one reason why climate change modelling and predictions by the Met Office are vital to road planners. Our work with the Highways Agency included developing risk analysis tools to help it make strategic decisions on maintaining and constructing roads as the climate changes.”

EUROCONTROL

The aviation industry is very sensitive to weather, so any longer term changes in weather patterns could have a significant impact on the industry. For example, climate change could affect the long-term planning necessary for new aircraft design, for the design and location of airports and even the routes planes take.

A project developed by Eurocontrol, the body responsible for the safety of air navigation in Europe, and the Met Office has studied the anticipated changes in weather patterns and their impact on the long-term plans and viability of the aviation industry.

"With many airports located at coastal sites and often on land reclaimed from the sea, any rises in sea-level could impact on their sustainability," says Kirsty Lewis, Principal Climate Change Consultant at the Met Office.

"Improved sea defences may be required to protect against the increasing risk of sea-level rise and extreme storm surges.”

Expected temperature rises, particularly in the Mediterranean region, could also impact on airport operations. Increasing temperatures throughout the 21st century will result in less snow and frost overall. But airports which operate efficiently during periods of significant snowfall today might need to subscribe to de-icing services in the future, as more moderate conditions mean that ice, rather than snow, could pose a greater problem for day-to-day operations.

The jet stream, which can dictate much of the weather over Europe and provides the upper-level high-speed winds that affect air travel, is also being studied closely. Already there is some indication that it is moving northwards over time, a move that will affect routing and flight times for the aviation industry.

"Understanding and predicting future weather patterns as the climate changes can lead to roads being designed and constructed to cope with the changes.”

Rob Harrison, Principal Consultant, Met Office
Planning strategy

Even if we stopped emitting greenhouse gases today, some changes in climate are already inevitable. But there is a choice in how large these changes will be.

Climate change is happening, and climate science from the Met Office adds to the evidence that early and rapid reductions in emissions are required to avoid significant impacts. One UK Government initiative, AVOID – or Avoiding Dangerous Climate Change through Stabilising Greenhouse Gas Concentrations, to give it its full title – aims to put the latest scientific knowledge about dangerous climate change into the hands of policymakers.

Some of the key questions that the AVOID programme is tackling are: How much climate change is too much? What level of global climate change should be avoided? What can be done to avoid dangerous climate change? What is considered an acceptable risk of climate change impacts for different regions and communities?

Funded by the Department of Energy and Climate Change and the Department for the Environment, Food and Rural Affairs, AVOID sees the Met Office working alongside three other leading climate organisations, the Tyndall Centre, the Walker Institute and the Grantham Institute for Climate Change at Imperial College. Its first objective is to provide supporting evidence to UK negotiators at the United Nations Climate Change Conference due to be held in Copenhagen in December 2009, where, it is hoped, a new international treaty on tackling emissions will be agreed.

The joint research will model future climate and look at the environmental, economic and social consequences of climate change and the dangers arising from it. The Met Office is providing a set of different scenarios to answer the key questions above while considering how to avoid an increase in global average temperature of over 2 °C, above which many consider dangerous.

"AVOID will encourage the integration of climate scientists, social scientists and economists, while making the latest climate science available to policymakers."

Jason Lowe, Head of Mitigation Advice, Met Office

'AVOID' AIMS
- Policy-relevant evidence and research needed to achieve international agreement on greenhouse gas emission reductions for COP15 (UN Climate Change Conference, Copenhagen, December 2009) and beyond.
- Core research for understanding dangerous climate change and its implications, including impacts, economic and social consequences and responses.
- A framework that will further encourage the integration and communication of scientific and socio-economic research on climate change.

'AVOID' BENEFITS
- The UK Government better placed to achieve international agreement on emissions reductions.
- Mitigation and adaptation policy even more strongly grounded in scientific evidence.
- Scientific information more accessible and relevant to a wide range of stakeholders.
- Research on all aspects of climate change more effectively integrated in the UK.
Preserving resources

Forests help to cool the climate, but when they are destroyed huge amounts of carbon are released into the atmosphere.

Deforestation is the third largest cause of emissions after energy production and industry and is more harmful to the environment than transport. Tropical forest cover declined by up to 2.5 million km² between 1980 and 2000.

ELIASCH REVIEW

In 2007, UK Prime Minister Gordon Brown commissioned the Eliasch Review to investigate how fast deforestation is taking place, the level of emissions resulting from it now and in the future, and the international financing required over the forthcoming years to help reduce forest loss. In contributing to the review, the Met Office analysed scientific data from a range of climate and deforestation scenarios, including what might happen if nations carry on destroying forests, or, alternatively, if measures are put in place to reduce deforestation.

In its research, the Met Office was seeking to answer several questions, including: To what extent does proposed development of the Amazon region lead to deforestation? What happens if rapid deforestation is not accompanied by protection of the forest? What is the effect if increased governance is employed and steps are taken to improve the forest? For example, improvement of the road network will result in increased deforestation, but if proposals include conservation areas, negative climate effects will be lessened.

To read the full Eliasch Review, published in October 2008, including the Met Office’s contribution to it, go to the UK’s Office of Climate Change website at: www.occ.gov.uk/activities/eliasch

GOING, GOING, GONE

Deforestation in the Tropics affects the climate because of the cooling effect of plants and trees. The destruction of tropical rainforest has been gathering pace since the 1960s, and still continues largely unabated. Deforestation was not included in the 1998 Kyoto Protocol on climate change.

In Amazonia the forest is mainly converted to farming land, principally for cattle and more recently for the production of soybeans. The construction of highways has led to further settlement and deforestation. It is said that at the current rate of deforestation, the Amazon rainforest could be reduced by 40% by 2030. Such large-scale deforestation is predicted to reduce regional rainfall.

Destruction of the rainforest affects the climate in three ways:

• Burning extensive areas of trees releases vast amounts of carbon into the atmosphere. Net deforestation has contributed 22–43% of the historical rise in carbon dioxide (CO₂).

• Forests are an important carbon sink. Without the world’s tropical forests, the rise in CO₂ could have been 10% faster than it has been.

• Forests cool the climate by constantly recycling water through the rain and evaporation cycle. Climate change itself threatens the rainforest as the climate becomes too dry to support vegetation. Unfortunately, this has been used as an excuse to encourage deforestation – still the greatest threat to tropical rainforests.

Richard Betts, Head of Climate Impacts, says, “Just because climate change may ultimately threaten the Amazon rainforest, this does not mean that we should give up on protecting the forest. Preserving tropical forests helps maintain an important carbon sink and significantly improves our chances of avoiding dangerous climate change.”

Deforestation has become a major political issue. It highlights an urgent need to negotiate agreements with countries where rainforests are located to achieve a global policy on preserving these vital resources.

At the current rate of deforestation, the Amazon rainforest could be reduced by 40% by 2050.

• The Amazon rainforest covers two-fifths of South America.

• It is a ‘carbon sink’, storing 90–140 billion tonnes of carbon.

• It has more species of flora and fauna than anywhere in the world.
Forecasting change

When it comes to forecasting the weather for today, tomorrow and next week, the Met Office provides very accurate advice and guidance.

At the other end of the scale, we’ve pioneered the use of our weather forecast model in predicting the climate towards the end of the 21st century.

In fact, our four-day forecasts are now as accurate as our one-day forecasts were 30 years ago. They rely on an accurate estimate of the current state of the weather, made by collecting observations from around the world each day. However, chaos limits the use of these weather forecasts to weeks at most.

Our one-hundred-year forecasts do not include observations of the current climate, but rely on factors such as increasing greenhouse gases to change its state. Unlike weather forecasts, we cannot check our climate predictions for accuracy against what actually happened. Instead, we check their ability to simulate the current and past climate, which gives us confidence in their ability to predict the future climate.

A key area of development at the Met Office is forecasting on the timescales in between – from months to decades. Many of our customers plan ahead on this basis. From months to years, the climate is influenced by the current state (particularly of the ocean) as well as increasing greenhouse gases. We use both of these factors to provide forecasts out to several months ahead and in our pioneering decadal forecasts out to 10 years ahead. Our aim is to be able to predict when climate change and natural variability will conspire to give extreme or even unprecedented events that pose a threat to humankind.
Science is at the core of all Met Office business. It underpins our role as a national weather service, the climate advice we provide to governments and the consultancy we deliver to businesses.

Science has provided us with unequivocal evidence that the emission of man-made greenhouse gases has committed the Earth to a level of climate change which cannot now be avoided. As this brochure shows, climate change will impact every aspect of our lives and lifestyles with the potential to alter them beyond recognition. Every country will be affected and the results of decisions taken today to protect environments, economies and societies from a changing climate will last many decades or even centuries, so it's important that we work together to get it right.

UK IMPACTS

The UK is already taking steps to adapt to unavoidable climate change. The UK Climate Projections 2009 (UKCP09) funded by the Department for the Environment, Food and Rural Affairs, saw the Met Office producing an ambitious and comprehensive analysis of regional climate change.

The UKCP09 projections provide probabilistic information on how the UK’s climate will change in the 21st century, based on cutting-edge climate models, observations and statistical analysis from the Met Office and using our expert knowledge. The projections are a key part of a programme of measures from the UK Government to both encourage and support action to prepare for the impacts of our changing climate. For more information visit www.ukcp09.defra.gov.uk

The projections are designed to inform policy- and decision-makers of the risks associated with different levels of climate change in their efforts to tackle future challenges. Used appropriately, they can inform risk-based decisions that avoid the dangers while making the most of the changes to come. However, the projections are complex and need to be interpreted very carefully, which is where the Met Office can help. We can add value to UKCP09 by tailoring the projections to organisations’ individual requirements; adding more detail by focusing on specific locations, variables or scenarios; and taking user-specific situations into account.

TOGETHER, WE’RE STRONGER

The UK has been at the forefront of research in the science of weather and climate for many decades. This standout is largely due to a unique and growing partnership between the Met Office and UK academia. The UK Climate Service strengthens this connection by bringing together the expertise of the Met Office with that of the UK’s universities and Research Councils. A project, already underway with the Natural Environment Research Council (NERC), recognises that climate change is no longer just an issue of scientific research but a major problem facing us all. The NERC-Met Office Joint Research Programme, launched in March 2009, aims to fill critical gaps in the UK’s portfolio of climate research to provide the best information and advice to those who need it – anywhere in the world.

The UK Climate Service will also play an important part in the UK’s major programme on Living with Environmental Change (LWEC), which aims to ensure maximum connection between environmental research and the needs of governments and businesses. This will be a further aid for policy- and decision-makers in understanding what climate change means for them and keep the UK at the forefront of international climate change science. For more on LWEC, visit www.lwec.org.uk

Over the past decade, the Met Office has developed a unique Unified Model™ that can simulate the weather and climate from a few hours to centuries ahead. The UM™ forms the basis of the UK Climate Service and helps to give the Met Office an international reach. The model is now being used by many different institutions around the world (currently in Australia, India, Korea, New Zealand, Norway and South Africa) for their short- and long-term forecasting needs. These international partners play an important role in helping the UM™ remain a state-of-the-art seamless prediction system that transcends the boundaries between weather and climate forecasting.

Together with our global network of partners across academia, institutions, governments and businesses, the Met Office is uniquely placed to provide climate science and services that address the needs of people everywhere. After all, the very survival of humankind is at stake.
Protecting your world

Answer these ten questions to see how working together can help protect your world.

Are you:

• seeking ways to adapt to the inevitable changes in climate over the 21st century?
• looking for sound business advice on the financial risks associated with the weather, climate variability and climate change?
• building climate change into your government policies, plans or strategies?
• factoring climate risk into your long-term decisions or investments?
• planning ahead for the opportunities that climate change may bring?
• considering how climate change might affect your workforce and customers?
• taking account of the ‘urban heat island’ effect, in addition to climate change?
• thinking about how changes in temperature, precipitation (rain, hail, snow) or extreme weather (high winds, storms, floods, heatwaves) might affect your personal health and prosperity?
• conducting research into weather and climate across all scales (global, regional and local) and timescales (daily, monthly, seasonal, decadal, centennial)?
• hoping to benefit from, or contribute to, the latest climate science and services from the Met Office?

If you’ve answered ‘yes’ to any of these questions, visit www.metoffice.gov.uk, email us at enquiries@metoffice.gov.uk, or call our 24-hour Customer Centre on 0870 900 0100 to find out how, together, we can make the right choices on climate change.