

Imperial College
London

outlook 2011



Grantham Institute for Climate Change

An institute of Imperial College London



FROM THE GRANTHAMS

Foreward

In a world where climate impacts are likely to fall hardest on the poor and most vulnerable, it is all too easy to feel discouraged by the apparent lack of progress in building a global consensus on climate change action.

Now, as international commitment to achieving the 2°C target seems even more fragile, the mission of the Grantham Institute to drive climate related research and translate it into real world impact is even more important. It is crucial that evidence is available for countries to make informed decisions on the pace and scale of their actions on climate.

We are pleased to be supporting this work and are delighted by the Institute's ambitious approach and its achievements described in the following pages.

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“...the efforts of leading research organisations like the Grantham Institute are vitally important to understand and respond to the scale, pace and potential implications of climate change.”

– Jeremy and Hannelore Grantham

FROM THE DIRECTOR

Making a difference

I am hugely encouraged in my role as Director of the Grantham Institute to see the vast range of climate related work going on here at Imperial and the very high quality of the people, both staff and students. Their ability and enthusiasm in making a better tomorrow shines through in so many areas.

I am delighted that several Grantham Institute academics and students were recognised for their high academic achievement and significant future potential by being awarded a College 2010 Research Excellence Award.

This year the Institute has added two important dimensions to its activities at the College. First, the incorporation of the UK node of the Climate-Knowledge and Innovation Community (KIC) into the Grantham Institute will provide a potentially seamless link from research to innovation. Second, the College has asked us to coordinate the Environment theme highlighted in its Research Strategy. This provides a great opportunity to achieve synergy



between climate change related activity, which will remain a major focus, and the broad range of excellent environmental research and education around Imperial.

Professor Sir Brian Hoskins
CBE FRS, Director
Grantham Institute for
Climate Change

FROM THE POLICY DIRECTOR

Rising to the challenge

An effective response to climate change will require potentially momentous changes, but not acting could be even more disruptive and costly. Unless the severity of projected climate impacts is given adequate weight alongside considerations of shorter-term economic prosperity, governments, businesses and individuals are all likely to do too little, too late.

The scale and urgency of the challenge requires that about 20 or so major emitting economies make radical transformations in their energy and transport systems over the next 40 years or so. But since the major low-carbon alternatives are more expensive than the existing predominantly fossil-based technologies, countries will not make the necessary changes unless the scientific, technological and economic evidence is convincing that:

- a business-as-usual economic growth path is no longer desirable or sustainable;
- adaptation alone is not a sufficient response;
- urgent mitigation action is needed, including in many developing economies; and
- we have feasible and affordable technological options to mitigate the worst of the risks.

Informing the debate

The Institute's policy activity therefore aims to provide authoritative analysis and assessment of this evidence and to communicate it in a policy-relevant way to decision makers and more widely to inform the often heated and polarised debates about climate change. A benefit of carrying out this activity within one of the world's leading research universities is that of impartiality. We are not lobbyists and, while we are motivated by our concern about climate change, we aim to adhere to the same high standards of objectivity, analysis and evidence that apply to other areas of Imperial's activities. And of course, in the UK and internationally, we are just one voice amongst many. We are very happy to work with partners who have complementary strengths and approaches.

Moving forward

The work of the policy team gained momentum in 2010. Particular highlights included: projects for the UK government analysing China and India's short-term voluntary mitigation targets and the potential for negative emissions technologies that can remove carbon dioxide from the atmosphere; four new Briefing Papers and a Discussion Paper; a special lecture by Dr Fatih Birol, Chief Economist at the International Energy Agency; and a briefing on Capitol Hill that I gave along with other members of the Scientific Team of the UK Met Office-led AVOID programme. Looking forward, 2011–12 promises to be just as exciting and productive.

Dr Simon Buckle, Policy Director
Grantham Institute for Climate Change



A year in the life of the Grantham Institute

MAY

What next in a world of denial?

Professor Chris Rapley CBE, Director of the Science



Museum London and Professor of Climate Science at University College London, called for action on

human-induced climate change at this year's Grantham Annual Lecture. Professor Rapley asked – in the face of overwhelming evidence for climate change – what should our response be and what's stopping us from taking action?

JUNE

Making a difference

Understanding ecosystems and their potential role in poverty alleviation is the central task of the Ecosystems Services for Poverty Alleviation (ESPA) programme launched as a joint initiative by the Research Councils and Government. As part of the Directorate that provides leadership to the ESPA programme, the Institute is working with the Universities of Edinburgh and Oxford



to ensure that the science and knowledge developed is of the highest quality and impact. Professor Georgina Mace,

Associate Director for ESPA Knowledge, commented "this innovative new programme will build on the best environmental science to provide new tools for the sustainable reduction of poverty."

JULY

Entrepreneurs of the future

Fifty international students embarked on the first Climate-KIC Summer School, a Contextual Learning



Journey where students heard about climate change innovation in three different European countries over the six-week period. This inspirational journey gave students the opportunity to meet with leading names in the scientific and business communities to discuss climate change adaptation and mitigation. Students participated in a number of activities designed to give them hands-on experience of how the latest science can be translated into new services and products that impact on our climate and economy.

may

june

july

august

september

october

november

2010

NOVEMBER

Making an impact

The first of four further Institute Briefing Papers on 'Road transport technology and climate change mitigation' was launched. These papers are an essential output of the Institute, translating and communicating the College's considerable expertise into a readily accessible policy briefing document. Other Briefing Papers this year covered: carbon capture technology (Nov), carbon dioxide storage (Dec) and solar influences on climate (Feb).



DECEMBER

Gauging the potential

Understanding the potential for deploying negative emissions technologies in the UK was just one of the challenges tackled by a team of Grantham Institute experts. This project formed part of the AVOID research programme led by the Met Office, providing key advice to the UK Government on avoiding dangerous climate change brought on by greenhouse gas emissions.

JANUARY

Glimpsing the future

Dr Fatih Birol, Chief Economist of the International Energy Agency, painted a picture of unprecedented uncertainty for global energy at a special lecture for the Institute. The starkest message came from the knowledge that the commitments made at Copenhagen and Cancun will not be nearly sufficient to contain global temperature increases to 2°C as a result of greenhouse gas emissions. Dr Birol pointed out that "we would need to double decarbonisation efforts, then double them again to keep emissions within 450 parts per million."



AUGUST

Flicking the switch

A study by the Grantham Institute's Dr Adam Hawkes showed that switching off lights, turning the television off at the mains and using cooler washing cycles could have a much bigger impact on reducing carbon dioxide emissions from power stations than previously thought. The study indicated that the figure used by

government advisors to estimate the amount of carbon dioxide saved by reducing people's electricity demand is up to 60 per cent too low.



SEPTEMBER

Capitol investment

Following a joint UK-US research workshop under the AVOID programme, Dr Simon Buckle,

Grantham Institute's Policy Director, was one of a five strong UK-US team who gave a briefing on climate science, mitigation and adaptation on Capitol Hill for Congressional Committee staff and others. Dr Buckle focussed on the feasibility of achieving ambitious mitigation targets, concluding that "a whole-systems approach was required that deployed a broad technology portfolio, integrated energy supply and demand and exploited demand reduction and efficient energy use."

OCTOBER

Securing our future

The new intake of Grantham PhDs began their research projects. Kathryn Lockett, for example, is investigating the complexities challenging the prediction of climate change impacts. "My research looks at the temporal and spatial effects of extreme climatic events on ecosystems and biodiversity."

2011

december

january

february

march

april

FEBRUARY

Tackling climate change in the UK

Sir Brian Hoskins, in his role as a member of the Committee on Climate Change, took part in the briefing of MPs and Lords on what the UK can do to tackle climate change and prepare for future impacts. This followed the launch of the Committee's advice on the fourth carbon budget.



MARCH

Life on Earth

In response to our invitation, Sir David Attenborough came to a crowded and enthusiastic meeting of our PhD students

for a question-and-answer session. When asked for his opinion on human-induced global environmental change, he said that expanding human population and rate of consumption were the major contributing factors. However, he did offer hope with the observation that the public was now showing an increasing interest and awareness of their impact on the planet.

APRIL

Extreme events

Developments in the modelling of extremes, the robust estimation of risk measures and the design of efficient risk-sharing schemes were just some of the topics discussed at the 'risk management and modelling



implications' workshop held in the College Business School. Contributors included leading experts in quantitative risk management,

statistics of extremes and atmospheric sciences, as well as regulators and representatives of the insurance and financial industries. There was a lively discussion on the role of model uncertainty and incentives to risk mitigation in light of recent extreme events ranging from Japan's Fukushima reactor crisis to Australia's Queensland floods and the global financial crisis.

Past climates

UNDERSTANDING THE PAST is critical for improving our predictions of climate. At the Institute we are embracing this approach in an effort to contribute vital understanding to developing new climate models.

Palaeoclimates

Dr Tina van de Flierdt is Senior Lecturer in isotope geochemistry. She uses trace elements and their isotopes in the oceans and in seafloor deposits to reveal past climates that are relevant to the current era of climate change. She is especially interested in the Pliocene, about 3 million years ago, when the Earth was 2–4°C warmer than today. She is also looking at the period 34 million years ago when the Earth flipped ‘from greenhouse to icehouse’, starting the modern era of ice ages, as a revealing contrast to what is happening today.

This work is part of a unique Grantham programme in oceanography, operating across six Imperial departments. It aims to make a significant contribution to this field by building important new mechanisms into ocean models and improving the modelling of links between the ocean and atmosphere. To understand climate change and in order to test and improve climate model performance, it is crucial that we get more information on the very different climates of the past and big changes that have occurred.

Dr van de Flierdt says that current research can also help answer the topical question of how stable the ice sheets of the Antarctic are. “Antarctica has a very complex geological history. Our work is starting to show that the ice in the Eastern Antarctic may not have been as stable as we had thought. That suggests scope for several extra metres of sea level rise.”

Dr van de Flierdt adds: “Being in the Grantham community has allowed me to meet people in areas such as ocean dynamics and marine ecosystems, which is unusual for me as a geologist, and opens up opportunities for truly interdisciplinary research.”



Dr van de Flierdt on an expedition to collect cold water corals in the Drake Passage, a body of water between South America and Antarctica. These corals are used to learn about water chemistry and water mass distributions in the Southern Ocean on glacial-interglacial timescales.



Understanding the origins of the East Antarctica Ice Sheet can provide valuable insights into its vulnerability to climate change.

The fingerprints of melting glaciers

Carys Cook is in the second year of her PhD in isotope geochemistry, working on sediments from the ocean off the East Antarctic ice shelf.

She explains that these sediments are debris from melting icebergs, gathered by glaciers as they scrape across the land. She says: “We use three different approaches to see where the ice came from. These use isotopes of the elements argon, neodymium and strontium to tell us the geological history of the rocks in these sediments, which allows us to identify their source. This

isotopic fingerprinting allows us to get insights that we could not gain by other means.”

Cook’s work is important because the East Antarctic Ice Sheet contains enough ice to produce around 55m of global sea level rise if it all melted, although this is unlikely. A significant area of this ice lies below sea level and is connected to the Southern Ocean. A combination of higher temperatures and higher seas could make it unstable.

“Grantham has allowed me to meet peers with similar motivation to me but from very different academic backgrounds,” says Cook.

Blue skies

DEVELOPING ANSWERS to the complex interactions within our climate system is key to improving global climate models. One area of continuing discussion is the interplay between the many factors that influence our atmosphere.

Solar forcing

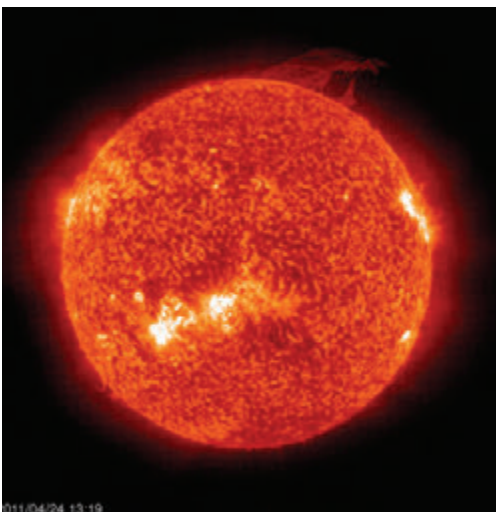
Joanna Haigh is Professor of Atmospheric Physics, and head of Imperial's Department of Physics. She is interested in solar forcing, the effects of small changes in the Sun's energy output on Earth's atmosphere.

The changes she looks at take place over the 11-year sunspot cycle. When the Sun is at its quietest, with fewest spots, it gives out about 0.1 per cent less energy than it does when at its most active. This does not sound like much but on Earth it can cause detectable changes.

Professor Haigh says: "Some of the most interesting effects are to do with regional climate variation. As the Sun gets more active, storm tracks in the southern and northern hemispheres each move towards the pole. Solar forcing also affects the North Atlantic. We get colder winters in Europe when the Sun is less active."

Her research is examining how solar output varies across the spectrum. She says: "In the ultraviolet we see far bigger variations in output, up to ten per cent across the solar cycle, than we observe overall. That can have big effects on the production of ozone in the stratosphere. A new satellite called SORCE is providing data on the whole solar spectrum from X-rays to the infrared."

Professor Haigh is in no doubt that human-induced climate change is real. "Even so, our new knowledge of the effects of solar variation has added significantly to our knowledge of the climate."



Research is helping us to understand how changes in the Sun's activity is capable of affecting Earth's climate. Image courtesy of NASA and the European Space Agency.



Atmospheric interaction

Alice Flint is in the third year of her PhD at Grantham. Her work uses a simplified model of Earth's climate, in which details such as oceans, mountains and clouds are not included, to show how the light upper layer of the atmosphere, called the stratosphere, interacts with its dense lower layer, the troposphere.

She says: "This simple model is good at replicating the actual temperature and circulation of the atmosphere. It allows us to see how heating and cooling the stratosphere can influence the troposphere. For example, it shows that atmospheric weather systems play an important role in the interaction between the two. For many years it was thought that the stratosphere was too light to affect the troposphere below. Now we are finding out that this is not true. This is important because with global warming, the troposphere heats up but the stratosphere cools down, and both can shift the position of the jet streams."

Flint has found that working at the Institute has allowed her to look at the wider impact of her research and provided a thriving international community in which to study.

Above: Grantham PhD student Alice Flint is investigating how different layers of Earth's atmosphere interact and have an impact on our climate.

An aerial view showing the extent of flooding in and around the city of Sukkur in Pakistan's Sindh Province. The image was taken from NASA's Terra spacecraft. The Indus River, Pakistan's longest, snakes vertically through the image.



Living with a changing climate

BY INTERFERING WITH THE CLIMATE SYSTEM we are performing a dangerous experiment with the planet. As we emit increasing amounts of greenhouse gases – especially CO₂ – into the atmosphere, we

can expect extreme heat and intense rainfall to occur more frequently. In general, people who have a lot of rainfall will get more, and those who have little will get less.

To reduce the changes in climate and more frequent extremes of weather, we need to develop a low-carbon economy, which will allow us to do what we do now but with drastically decreased emissions of CO₂. To achieve this, countries will need to invest in low-carbon technologies and increase the resilience of their societies. An understanding of the economic impacts of mitigating and adapting to climate change will be crucial.

Unexpected extremes and their mechanisms

In the 2010 northern hemisphere summer, Russia and Pakistan suffered climatic extremes. Hot winds from the south and clear skies associated with high pressure over Russia, caused a heat wave thought to have killed many, and resulted in large scale crop failure and damaging forest fires. The same weather pattern saw air in the higher atmosphere move from the north towards north-west Pakistan. Lower down in the atmosphere, warm moist monsoon air came up from India. The combination resulted in extreme rainfall and disastrous floods across Pakistan, affecting 20 million people.

Extreme weather of a different kind occurred in the winter of 2009-10 and also in December 2010, both of which were unusually cold in the UK. Like the summer heat wave in Russia, they were both associated with the persistence of a so-called blocking high pressure system. In April 2011 a similar persistent weather pattern led to record warmth and drought in the UK.

If the frequency of occurrence of such persistent weather patterns is being influenced by increased greenhouse gases in the atmosphere, says Grantham Director Sir Brian Hoskins, then the current estimates of the impact of climate change would be much too low. Climate models may start to give more reliable information on this in the next few years.

Research at the Grantham Institute, in collaboration with the University of Reading, is examining such extreme events and what might be expected in the future.

Economic impacts

International negotiations on climate change have focused on mitigation. However, insufficient mitigation is likely to make adaptation to the effects of climate change more necessary. PhD student Jörg Leib's research aims to create a model that analyses how this might affect future negotiations.

Mitigation has disadvantages that make countries reluctant to invest in it. It is expensive for each country, yet benefits each only a little because the results are shared amongst all. It also takes a long time to show any effects. Adaptation, although not seeking to stop climate change, is in some ways more attractive. Most projects are implemented locally, and bring quicker, more obvious benefits to those who carry them out.

Economists model how much countries should spend on mitigating climate change to maximize human welfare over time. Jörg Leib is researching ways of adding and entwining mitigation and adaptation within an innovative economic-climate model developed by his supervisor, Dr Simon Buckle at the Grantham Institute, that yields new insights into the international climate negotiations.



Jörg Leib discussing the economics of mitigation and adaptation.

Insuring our future

INSURANCE INDUSTRIES PUT ASIDE CAPITAL EACH YEAR to enable them to survive occasional disasters. In calculating how much capital they need to save, they use historical data to make assumptions about the frequency of extreme events. Past disaster rates are projected into the future. With climate change, however, and the increasing frequency of disasters, these calculations break down. Already, catastrophes put some insurance companies at risk of default because they are not prepared for the severity of events.

Insurance and capital market solutions

Dr Enrico Biffis is Assistant Professor in Actuarial Finance at Imperial College Business School. He models the design of insurance policies and other risk-sharing mechanisms in the face of increased uncertainty caused by climate change.

Insurers play an important role in helping the implementation of climate change policies, by inducing consumers to improve resilience to climatic events. In private insurance markets, the price of coverage is risk-based. Hence customers can link the price of a policy with their exposure, and this may encourage them to take measures to reduce their risk. Otherwise their insurance may be more expensive, or even impossible to obtain.

The effects of extreme events may be very complicated. The damage to Japan's Fukushima nuclear power plant in early 2011 was the result of direct and indirect effects: an earthquake followed by a tsunami, with various structural factors at the plant and possibly human error. Such an event illustrates how very difficult it is to model future uncertainties and complex hazard/loss relationships.



The Lloyd's building, London. In the face of our changing climate the insurance industry will need to adopt new methods for risk management.



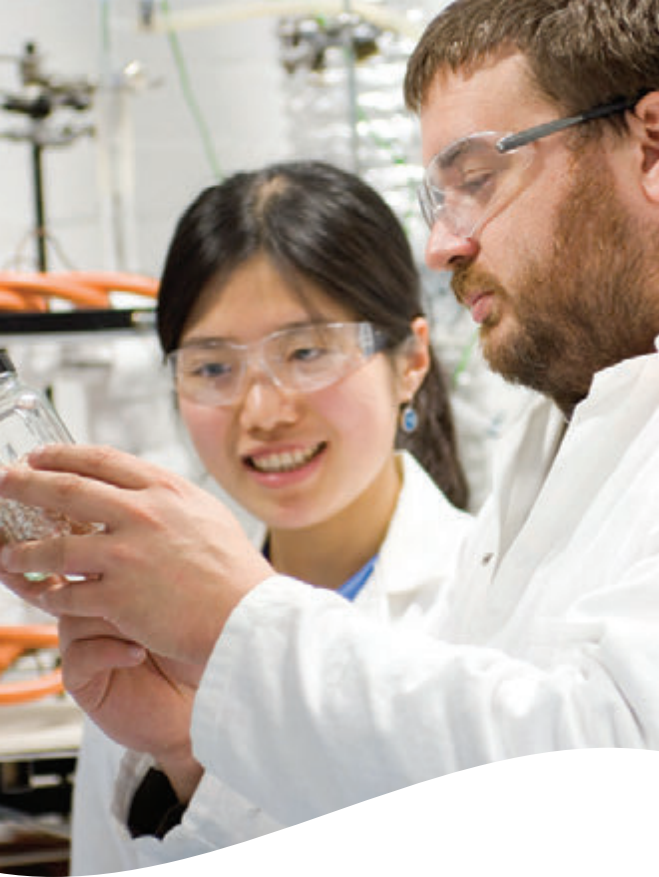
Carbon trading

Jan Ahmerkamp is in the second year of his PhD, based in the Imperial College Business School. He is a financial economist and is working on the new field of emissions trading, the business of selling permits to emit carbon.

Ahmerkamp's main interest is in the European Emissions Trading Scheme (ETS) that has been running since 2005 and is the world's biggest and longest-established trading scheme. He says: "Even this scheme is comparatively new and design changes are required. I hope the model I am producing will help in the design of future schemes. The aim of ETS is to encourage investment in low-carbon technology, but at the moment the energy companies say there is too much uncertainty for them to do this." A new phase of the European scheme is to be introduced in 2013.

Ahmerkamp adds that Grantham is valuable to him for its business links to energy companies, but also because it allows him to learn from a wide variety of scientists with an interest in climate change.

Above: Jan Ahmerkamp is examining potential options for improving existing Emissions Trading Schemes in Europe.



Technology options

AS WE MOVE TOWARDS A LOW-CARBON ECONOMY we will be faced with a growing demand and cost for energy that will need to be managed. Jenny Nelson, Professor of Physics at Imperial, is developing ways of assessing the energy costs of new technologies while they are still at the research and development stage. A production model for, say, plastic photovoltaics assesses the average energy costs of the lifetime of the technology, and identifies which components are likely to consume the most energy. Researchers can then ask whether they can replace those components with others that use less energy. They can thus look at new ideas for new materials or processes, compare them with what is currently expected to be used, and see what impact they would have on reducing CO₂ emissions.

Improving carbon capture

Capturing the carbon released by burning fossil fuels is crucial for reducing CO₂ emissions. PhD student Danlu Tong researches ways of making the process more efficient.

During carbon capture, the solvent monoethanolamine (MEA) reacts chemically with CO₂ and absorbs it. The reaction is reversible, and the CO₂ is then driven off by heating the CO₂-amine. The MEA is finally recycled through the process.

MEA has several disadvantages. It needs a substantial amount of externally-applied heat to release the CO₂. It is prone to degradation so it has to be replaced, and it also produces corrosive by-products.

Danlu Tong has been looking for a better solvent. Using 2-amino-2-methyl-1-propanol (AMP) makes it easier to reverse the reaction, although the reaction itself is slower. She is experimenting with adding piperazine, and the blend is looking promising, absorbing larger amounts of CO₂ and faster than the original MEA.

The design process depends on the thermodynamic properties of the solvent, but the measurement of their values cannot be achieved very accurately. Tong has also improved the accuracy of these measurements.

Above: Dr Paul Fennell with Danlu Tong inspecting limestone-derived sorbents for CO₂ capture.

Fuel efficiency

Dr Ricardo Martinez-Botas researches technologies that will reduce CO₂ emissions from road transport. This accounts for 90 per cent of the UK's domestic transport-related greenhouse gas emissions.

One project will produce more efficient, smaller engines, which would provide the same power output and acceleration as current larger engines, potentially saving up to 35 per cent of fuel consumption. A project led by the global engineering provider Ricardo plc, with Ford UK as the lead vehicle developer, will reduce the mid-class vehicle engine from 2 litres to 1 litre by the end of this year. This car should cost only slightly more than the current model, and be much cheaper to run. Longer term, a Jaguar-Land Rover engine will be reduced from 5 litres to 2, again maintaining its performance and this time addressing a different vehicle market sector.

Along with decarbonisation of the electricity grid, plug-in hybrid electric cars could reduce fuel usage further. Dr Martinez-Botas researches the thermal analysis and management of their electrical motors and storage, aiming to reduce the level of cooling while ensuring that the engine does not overheat and that the energy flows are optimised.



Imperial's Racing Green Endurance car, SRZero, reached the end of its 26,000 km journey across the Pan-American Highway in November 2010. The project was developed to highlight the potential of electric vehicles.



Predicting the impact of a changing climate on our water system will help us to develop appropriate strategies for managing this precious resource.

Managing our resources

The highlands of Ecuador and Colombia are wet: their annual rainfall may reach 4 m. With soils that store water, they act as ‘water towers’ for drinking, irrigation and hydropower for the people of Quito and Bogota, at lower altitudes. Farmers, however, are moving to highland areas to grow their potatoes and beans, and to graze cattle more intensively than before. Their mechanized cultivation could pollute the water supply; climate change could decrease the soil’s capacity to store water.

Research Fellow Dr Wouter Buytaert is a water resources engineer who studies the impact of these changes on local water resources. His aim is to alleviate poverty by simulating and predicting what will happen to water resources under current and future conditions. In the absence of complete data, he and his colleagues are trying to integrate their observations into environmental software algorithms to establish a virtual observatory, a tool which will allow local decision makers to access existing data, and design strategies for collecting and managing more.

“The work is very interesting scientifically,” says Dr Buytaert, “because you have to deal with processes that are not well understood, so there’s scope for increasing understanding. There’s a big discrepancy between the little we know about these ecosystems and the strong reliance of people on the services they provide.”

Sustainable water resources

CITIES USE WATER FROM RIVERS, river basins and groundwater reservoirs that extend far beyond the cities themselves. Using this water will impact on other ecosystem services: a thirsty city may compete with farmers who need to irrigate, for example, and reduce their food supplies. Taking water from a river may affect its biodiversity, its recreational facilities and the local economy. All of these ecosystem services interact, and some might jeopardize others. Climate change will affect them all.



more extreme an event, the more the uncertainty associated with it.

Floods will be more dangerous when they occur, but there will be long, dry periods between them. This presents challenges for planners having to prepare flood defences. Similarly, people planning infrastructure for water supplies need to know whether to build bigger tanks. When more is known about the uncertainty associated with extreme events, social scientists can use the information in a cost/benefit analysis that will enable the planners to understand more about the decisions they have to take.

Understanding the global water cycle

Kwok Pan Chun is doing his PhD on how the global water cycle will be affected by climate change. He wants to enable water storage experts, or people who build flood defences, to make better decisions.

Climate change will bring more extremes, and the atmosphere will carry more water. As the amount of water on Earth is constant, it is the distribution of it that will change. Pan Chun’s research concentrates on predicting the intensity, duration and frequency of rainfall in events such as floods. His research shows that the

Above: As our climate changes, so will the frequency and intensity of extreme events such as flooding. Understanding the science behind these events will help countries to determine and plan for the appropriate response.

Using an integrated approach to control infections can help reduce the spread of disease carried by mosquitoes.

Integrated disease control

Hannah Slater is in the final year of her PhD. Her subject is the spread of malaria and lymphatic filariasis, two damaging tropical diseases spread by the same genus of mosquito.

She is modelling the spread of these diseases, the effectiveness of steps taken to limit them and the potential for a combined control approach that targets both infections. Some technologies, such as bednets that prevent the mosquitoes from biting people, can be effective against both diseases. Beneficial intervention is also possible by treating people with malaria at an early stage of the condition, when they are most likely to infect other people, and by treating pregnant women, which reduces the chance of their children getting malaria.

Slater says that her models have up to 30 variables, some pulling in different directions. "With climate change, we find that mosquitoes bite more at higher temperatures but they also die off faster. I aim to quantify these effects and see which is dominant. We also know that mosquitoes often lay their eggs in puddles. Some climate change models predict much more rain in West Africa, which means more standing water and possibly higher mosquito density."

Human wellbeing

UNDERSTANDING THE EFFECTS OF CLIMATE CHANGE on the human race is just one of the major challenges we face in society today. Here at the Grantham Institute we are looking at the stresses on human populations from issues such as food supply and the salination of drinking water. Climate change adds to these pressures, as the death toll from the French heatwave of 2003 shows. We have a programme on drinking water in Bangladesh that connects sea level rise with raised drinking-water salinity and heart problems in the local population.

Environmental impacts

Grantham researchers are applying lessons from other species to the future of the human race. Professor Tim Coulson is a Population Biologist whose species of choice has been the Soay Sheep, found on the island of Hirta off the coast of Scotland. "These are an ideal animal to study because even in the wild the system is a very simple one with no other large animals present," he explains.

The size of the Soay population depends on variables such as survival rates, birth rates, and dispersal rates if animals can move away. These in turn depend upon the environment and the availability of resources such as food and water, and on the genetics of the species in question. The climate on Hirta is now warmer because of climate change. So there are more Soay Sheep but their average weight has dropped. Smaller sheep that would once have died in the winter can survive today's warmer conditions.

Although humans have self-awareness which other species lack, they take decisions on the basis of the same pressures. "They can have fewer children in response to resources getting less available, or they could decide to fly less or buy less food from far away," says Professor Coulson. "Birth rates have fallen in response to economic change, especially as a result of more access to education for women. This eventually brings down population numbers, but has a cost because richer people use more resources."

He adds: "We used to think that ecological change was fast but evolution was slow," he says. "Our work now suggests that in some situations, humans and other species can evolve rapidly under resource pressure."



Milder winters are causing Scotland's Soay sheep to decrease in size.

Ecosystems in a changing climate

ECOSYSTEM SERVICES, THE THINGS THAT THE ENVIRONMENT PROVIDES FOR US such as clean water and soil fertility, play a crucial role in supporting populations across the globe. Climate change affects the environment's ability to provide these services, something that can take a long time for the ecosystems to recover and adapt to. It can take years for a new environment to stabilise and get beyond an impoverished ecology of weedy plants to provide a full range of useful specialist ones. Our research into these impacts and how we manage such services will provide new insight in tackling the impacts of climate change.



Professor Milner-Gulland's research suggests that Saiga antelope conservation areas may need to be reviewed in light of climate change impacts on their ecosystems.

Conserving our ecosystems

EJ Milner-Gulland is Professor of Conservation Science. Her group's work uses a mixture of modelling and fieldwork, which feed and improve each other. She says: "We work with non-government organisations and governments around the world to address practical problems. An important part of our research is to examine how our recommendations worked out in practice and feed that back into our models."

Milner-Gulland's work with the Saiga antelope illustrates this approach. This migratory creature ranges across the steppes of Russia, Uzbekistan, Kazakhstan and Mongolia. It was conserved in the Soviet Union, but poaching led to its numbers falling by 95 per cent after the USSR collapsed. She says: "Saiga horns are in demand for Chinese medicine, so hunting boomed once the border with China was opened. But they are hardy creatures and can bounce back even from this population loss."

Because the Saigas migrate over long distances, their ecology is easily disrupted, as has happened with migratory species around the world. But the steppe is large and retains a lot of biodiversity.

Climate change adds a further layer of complication. "Our work suggests that if the climate gets warmer and wetter, the existing conservation areas for the Saigas may be in the wrong place," says Milner-Gulland.

She adds: "I have found Grantham incredibly helpful. We are doing work on the link between fishing and rice harvesting at a lake in Madagascar. It was invaluable to link up with economists who could tell us about the strategies people adopt when a system like that alters with climate change."



Ellen Fry is studying the effects of climate change on the biodiversity of grasslands.

Climate change and biodiversity

Ellen Fry is completing her Grantham-funded PhD at Silwood Park, Imperial's biology campus outside London, and enjoys Grantham's emphasis on multidisciplinary research.

She is looking at the effects of climate change on grasslands, one of the world's most important ecosystems. For example, different plant species have roots of differing depth. As rainfall patterns alter with climate change, plants with deeper roots might be better-placed to cope with drier conditions.

Fry's work uses a system of rainwater shields to vary the water supply to plants in a field. This allows her to see how species cope with stress. Her initial findings, she says, suggest that "losing species is always a bad thing." The idea that one species can take over when another vanishes should be treated with caution.

Fry says that grasslands are a huge store of carbon. If they become degraded, this carbon could find its way into the atmosphere and accelerate climate change. Grass is also a major source of animal fodder, so changes to grassland affect human food supplies.

These changes can have severe economic consequences. If it gets too dry for coffee to be grown successfully in West Africa, for example, there would be financial effects on whole communities.

“The Grantham Institute’s role as a research and policy hub has opened up new unique opportunities for me, including technical collaborations with the UK Department of Energy and Climate Change and the Met Office.”



“The breadth of the Grantham community enables me, as an engineer, to get the overall picture of the problems we are all working to tackle.”



Join the Grantham Community

To find out more about the different ways in which you can be involved, please contact us at grantham@imperial.ac.uk



“As a pure economist, the Grantham community not only brings me the chance to learn about the scientific views of climate change, but also provides me with the opportunity to share the economic approach with scientists.”



“As a bridge between cutting edge research and policy making, the Grantham Institute provides an excellent platform for communicating research and building relationships with people across the wider subject of climate change.”

Media round-up

Grantham people and research regularly feature in the international media. Here are a few examples of recent coverage: you can read more at www.imperial.ac.uk/climatechange/news



Setting the record straight

Making headlines across the world, Dr Adam Hawkes’s research in *Energy Policy* highlighted that simple energy savings, such as switching off your lights and TV, could have a bigger impact on reducing carbon emissions than originally thought. July 2010.

Understanding ecological effects

The launch of a major new experiment on deforestation, biodiversity and carbon cycling in Malaysia, led by researchers at Imperial College, is covered by the international media. April 2011.





Sir Brian Hoskins speaking to talented researchers about environmental risk at an AXA Research Fund event in November 2010.

Working together

OUR PARTNERSHIPS WITH THE PRIVATE AND PUBLIC SECTOR are essential for ensuring the relevance and quality of research in the Institute and for maximising the impact of our work.

We are working with several commercial organisations to help them to develop their response to the threats and opportunities associated with climate change. One such company, Sainsbury's, in partnership with the Institute and Imperial's Faculty of Engineering, has created a new Smart Grid store in Hythe which activates the site's biofuel generator when there is a higher demand for power. As a result, the strain on reserve power stations is eased, contributing to a reduction in the UK's carbon footprint.

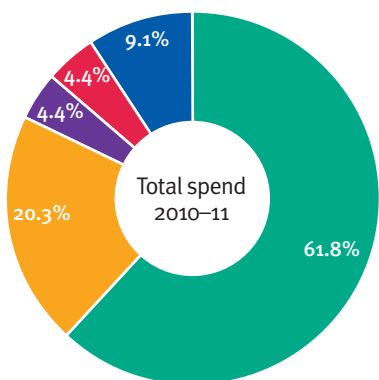
In another partnership, the Institute along with the Universities of Edinburgh and Oxford was selected to establish the Directorate for a new Government programme to drive the provision of new knowledge and tools to help decision makers manage the trade-offs that exist between ecosystem changes and development in poorer nations.

We also work closely with learned societies and professional bodies to raise awareness of climate change issues through publications and events. The Institute's Director, Sir Brian Hoskins, was one of the key scientists involved in the Royal Society's new guide to the science of climate change. The guide summarises the current scientific evidence on climate change and its drivers, highlighting the areas where the science is well established, where there is still some debate, and where substantial uncertainties remain.

We hope that you have been enthused by the activities described in 'Outlook 2011' and will want to partner with us – this may be as simple as attending one of our events, through to supporting a scholarship or sponsoring a research programme. To find out more about the different ways you can be involved with us, please visit our website at www.imperial.ac.uk/climatechange/getinvolved or contact us at grantham@imperial.ac.uk

Investing in climate change research

The research spend, including studentships, has remained at the 2009–10 level, while the percentage spend on policy activities has increased in line with the Institute's strategy.



- Research
- Policy activities
- Outreach and Communications
- Leadership
- Administration

Sun spots

Media report widely on a study by Professor Joanna Haigh and co-workers on the impacts of solar activity on Earth's climate. October 2010.



Going green

Sainsbury's partnership with Imperial's Faculty of Engineering and the Grantham Institute makes it into the news with the creation of their Smart Grid store in Hythe. February 2011.



Winter chills

Sir Brian Hoskins spoke to the *Sunday Times* about the reasons behind our unusually cold winters and what to expect next. December 2010.





Grantham Institute for Climate Change

The Grantham Institute was founded with a mandate to drive forward climate change-related research, translating this into impacts and communicating our knowledge to help shape decision-making. The Institute is integrating researchers and capabilities from all areas of the college necessary to tackle the challenges of climate change, through which we will work to offer practical scientific and technical knowledge of the highest quality.

Grantham Institute for Climate Change
 South Kensington Campus
 Imperial College London
 London SW7 2AZ
 UK

T: +44 (0)20 7594 5111
 E: grantham@imperial.ac.uk
 W: www.imperial.ac.uk/climatechange

About Imperial College London

As the only UK university to focus entirely on science, technology, engineering, medicine and business, Imperial College London offers a critical mass of international research expertise and a vibrant home for innovation and enterprise. Imperial is committed to making sure that its research improves quality of life and the environment.

Sustained support for Imperial's climate change research is a sound investment in environmental improvement, and in developing the next generation of climate change pioneers, researchers, innovators and entrepreneurs.

Climate change regularly features on Imperial's home page at www.imperial.ac.uk, which is visited by over 1 million people each month.

