Imperial College London

outlook 2010



Grantham Institute for Climate Change

An institute of Imperial College London

“...the world may finally be ready to act on climate change, and when it does it is critical that action be based on the very best science, economics and policy available. We believe that Imperial is particularly well qualified to provide this.”

– Jeremy and Hannelore Grantham

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FROM THE GRANTHAMS

Foreword

CLIMATE CHANGE IS AN ISSUE OF TREMENDOUS scale and complexity. Addressing it effectively requires new approaches to developing and implementing world leading science and technologies. We are delighted to introduce this report from the Grantham Institute for Climate Change at Imperial College London, which highlights the progress and contribution made by the Institute since it was established in 2007. Its work in developing and delivering new approaches through partnerships within and outside Imperial is making a real difference in our response to climate change.

Our foundation, the Grantham Foundation for the Protection of the Environment, is focused on supporting organisations that are working to find solutions to protect and improve the health of the global environment. We believe climate change is the most important environmental problem we currently face, and half our funding is devoted to addressing it.

We are pleased therefore that some of this support has been used to establish the Grantham Institute, which we judge is unique among climate change centres, situated as it is at the heart of Imperial College London – the only UK university to focus entirely on science, technology, engineering, medicine and business.

As this publication highlights, the Institute has demonstrated its ability to draw on Imperial’s high quality expertise to become an ideas leader, generating high quality research, creating the next generation of climate researchers, and translating and communicating science and technology into responses that impact on policy.

We hope this publication will inspire you to find out more about the Institute and Imperial, and how you can work with us to make a difference.

FROM THE DIRECTOR

Making a difference

GOOD RESEARCH AND POLICY REQUIRE good people, inspiring surroundings and time to find their feet. Here, in the Grantham Institute at Imperial College London, we aim to foster all three, to create an environment in which colleagues, at all stages of their careers and from all disciplines, can discover common ground, generate new ideas and apply new thinking. In the three years since the Institute was founded, we have been laying the foundations of our programme and building networks for those who are looking for new and better ways to respond to climate change.

Recruiting established world class scientists, as well as the research leaders of tomorrow, has been a particular priority for us in our early years. I am delighted that we have been joined by 15 new academic and research staff, and that our bright, thriving cohort of PhD students is now 37 strong. It is a pleasure to take this opportunity to present highlights of our recent work (pages 4–5), introduce you to some of our researchers (pages 6–13), and engage you in our aspirations to establish new partnerships and accelerate the contribution that we can all make to tackling climate change (page 14).

We will continue to invest heavily in our research, to improve our fundamental understanding of the pace and scale of climate change and to find better ways of mitigating its effects. We will particularly focus on water (including oceans and monsoons), earth observation, low-carbon transition pathways, biodiversity, ecosystems services , storm tracks and risks. We will continue to ensure that our work feeds into policy and public debate, and that we provide direct advice for government and other organisations wherever possible. We remain committed to serving society by ensuring that our research ultimately helps those whose lives are likely to be most affected by this pressing global challenge.

We remain acutely aware of the need to work closely with other organisations to bring about real change. We continue to enjoy research collaborations with our partner institutions in the UK and abroad, in particular with our Grantham-funded partners at the London School of Economics (LSE) and the Indian Institute of Science in Bangalore. Building on the generous support we receive from Jeremy and Hannelore Grantham, we are pleased to have recently set up the first in what I hope will be a range of new partnerships with businesses that include Sainsbury’s and Old Mutual. We are also looking to establish new collaborations through last year’s major European funding success for the Climate Knowledge and Innovation Community (KIC).

We continue to welcome public opportunities to discuss our research – to be open about what we know, where uncertainties lie, and what we have yet to discover. We have spent time working with the international media to encourage people to start thinking about ways that each of us can change how we live to make a difference, and we have participated in public events, such as the Royal Society’s Summer Science Exhibition.

Finally, I am pleased to report the publication of our first briefing and discussion papers, in which we share perspectives on key climate change issues and new ideas linked to our research. The first two papers, on solar energy and climate change in Africa, will soon be joined by others on the science of climate change, as well as options for mitigation and adaptation. They are a key addition to our work in ensuring that policy, business and public decisions are based on the best scientific evidence available.

Professor Sir Brian Hoskins CBE FRS, Director
Grantham Institute for Climate Change
May 2010

A year in the life of the Grantham Institute

MAY

Indian partnership

Director Professor Sir Brian Hoskins visits the new Grantham-funded Divecha Centre for Climate Change at the Indian Institute of Science in Bangalore to set up a partnership. The Indian monsoon features high on the agenda for research collaboration. "There's general agreement that intense rainfall is likely to get more intense, but we need to know more about how the characteristics of the monsoon will change as a result," says Sir Brian.

JUNE

Hands-on for solar energy

Grantham Institute publishes its first briefing paper, on solar energy, to coincide with Imperial's solar cell physicists exhibiting at Royal Society's Summer Science Exhibition. Dr Ned Ekins-Daukes, leader of the Quantum of Sol exhibit, says: "We are giving people the chance to get a hands-on understanding of research to develop new solar cells that capture the light missed by other solar panel designs."

JULY

Climate camp

Twenty international Climate Champions visit the Grantham Institute as part of a British Council climate camp to train talented young people in communicating climate change. The Champions come from France, Italy and Germany to meet researchers working on sustainable transport, new ways of producing liquid fuel from plants and technologies for capturing solar energy.

AUGUST

Recalculating costs

The Grantham Institute teams up with the International Institute for Environment and Development to highlight a substantial underestimate of the costs required to adapt to climate change. Grantham visiting research fellow Professor Martin Parry, one of the report authors, recommends that recalculations should include key sectors such as energy, manufacturing, retailing, mining and tourism.

SEPTEMBER

Smart energy futures

PhD students begin research into better ways of decarbonising the energy system. The scheme is run jointly with Imperial's Energy Futures Lab (EFL). "We are delighted to co-host these students: securing sustainable energy supplies will require multidisciplinary skills and solutions," says EFL Director Professor Nigel Brandon.

OCTOBER

Expect the unexpected

Sir Gordon Conway, Imperial's Professor of International Development, calls for organisations to work together and increase communities' resilience to climate change, in the Grantham Institute's first Discussion Paper. Sir Gordon says that predicting the impact of climate change in Africa presents a unique set of challenges: "It means having to prepare for the unknown. The key is helping people develop more resilient lifestyles and livelihoods."

2010

january · february · march · april

2009

may · june · july · august · september · october · november · december

NOVEMBER

Creating an impact

The Higher Education Funding Council for England announces £2.9M to analyse the impact of social sciences on issues including public responses to climate change. The consortium includes the Grantham Institute and is led by the London School of Economics (LSE). Professor Sarah Worthington, LSE Pro Director for Research comments: "When universities are increasingly being asked to demonstrate the impact of their research on the economy and society, it is imperative that we develop better methods for tracking and monitoring impacts."

DECEMBER

Climate KIC awarded

After Copenhagen, good news comes from the European Institute of Innovation and Technology, which signals Europe's commitment to tackling climate change by creating the Climate Knowledge and Innovation Community (KIC). Grantham Institute plays a major role in shaping the successful multimillion euro bid. Professor Sir Brian Hoskins says: "It's a massive task to reduce carbon emissions across the world and ensure that we are also able to adapt local, national and continental changes that are coming our way."

JANUARY

Mumbai TechFest

Imperial solar cell technology is a big hit with audiences of all ages at Techfest in Mumbai, attracting interest from Indian companies and members of the general public. The Grantham team includes Dr Balarko Chaudhuri from Imperial's Department of Electrical and Electronic Engineering, talking here to Indian children about ways of making future energy supplies more sustainable.

FEBRUARY

Mutual benefit

International long-term savings group Old Mutual plc awards a PhD scholarship to Imperial student Giovanni Rapacciuolo to look into how climate change alters species distribution and agricultural systems. Helen Wilson, Head of Corporate Social Responsibility at Old Mutual, says: "At the core of Old Mutual's approach to business is our belief that everything we do needs to lead to long-term sustainable growth. With the immediate pressure on the environment we are pleased to be able to support a Grantham PhD student at Imperial College London."

MARCH

Retail therapy

Imperial and Sainsbury's announce a partnership to help the supermarket reduce its carbon footprint. Grantham Institute and Imperial's Faculty of Engineering are both involved in the collaboration, which aims to address some of the most urgent climate change issues in the consumer retail sector. Neil Sachdev, Commercial Director for Sainsbury's, says: "We are delighted that Imperial is working with Sainsbury's in this partnership. The challenge of climate change needs bold leadership but ultimately it is action that counts and I am eager to see this relationship bear real fruit."

APRIL

Science Museum exhibit

Grantham PhD students provide research briefing on the development of global climate models to the Science Museum in London as part of the Grantham Institute's collaboration with the Museum on its new climate science gallery. "Our objective is to minimise the shrill tone and emotion that bedevils discussion of this subject", says Museum Director Professor Chris Rapley. "We seek to satisfy the interests and needs of those who accept that human-induced climate change is real, those who are unsure, and those who do not."

Ocean dynamics

WE NEED TO UNDERSTAND HOW the different elements of the climate system interact to generate climate change at regional and local levels. This calls for better models, and for the kind of interdisciplinary collaboration championed by the Grantham Institute.

Ocean modelling

Grantham Institute researcher Dr Pavel Berloff is a reader in Applied Mathematics and a specialist in ocean dynamics. He says: "The Grantham approach is an inspired one, both because of its interdisciplinary nature, and because the institute is run by a practising scientist".

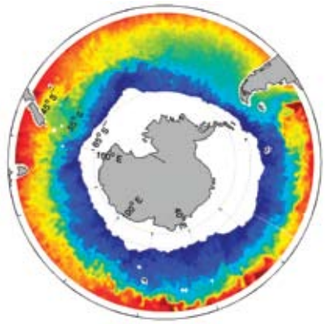
Dr Berloff has a strong interest in small ocean eddies, which he says are "the weather of the ocean". The difference from the weather in the atmosphere is that these eddies, which can be 10 to several hundred kilometres across, are far more numerous than cyclones and anticyclones, and we know far less about them. Despite this, we are now getting models that can simulate these eddies in the short term.

Dr Berloff is also interested in internal gravity waves that travel through the deep ocean, much as waves travel at the sea surface, and which break to form surf within the ocean. Like small ocean eddies, these are important mechanisms for mixing heat, as well as carbon and other chemicals.

Dr Berloff says: "The ocean is one of the most computationally intense problems in modern science. In addition, we have only 15 years of good satellite data on small ocean eddies, and we are only starting to get good data on internal waves – we're still in the stone age of ocean modelling."

Data on ancient climates is expanding our knowledge of the oceans, says Dr Berloff. Information on the climate years ago can be obtained from ice cores, ocean sediments and deep drilling. More importantly, "computer modelling will go beyond the stone age in the next few decades, and into the era of the first metal tools. The scientific challenge of modelling the oceans may take 50-100 years to overcome. But we have learned enough in the past to predict events like El Niño in the Pacific, and we hope to learn enough in the future to make predictions over decades."

This will mean that models of the oceans will improve, leading to better models of the whole climate system, so that policy makers will be able to look at the issue with increasing confidence.



Simulating waves and eddies

Grantham PhD student Ute Hausmann is also studying small ocean eddies, in the Atlantic and Southern Oceans, to understand the interactions between the oceans and the atmosphere. The eddies spin off from the unstable edges of mass movements of ocean water such as the Gulf Stream. Some travel the full width of the Atlantic.

Hausmann describes these eddies as "the ocean's mixing mechanism": as they move, they carry heat, salt and nutrients with them. Her PhD is on the interaction between eddies and atmosphere, and especially how heat might be transferred to the atmosphere. She is using increasingly rich data from satellites and ships, which provide further insight into eddy properties, including height, temperature and chemistry.

Hausmann says that small ocean eddies are an important part of the climate system, which we need to understand. As well as setting oceanic depths into motion, they may have a role in mediating the response of the oceans to changing atmospheric circulation brought about by climate change.

Above: Snapshot of Southern Ocean surface temperatures recorded on NASA's AQUA satellite. Colour scale: -1 to +15 °C

Model behaviour

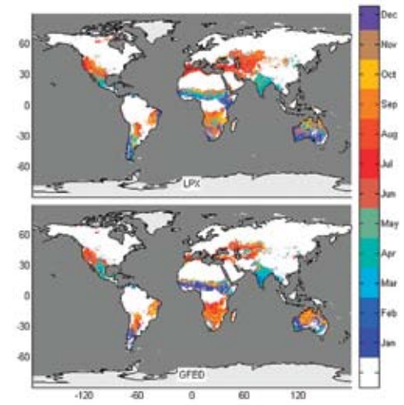
SOME OF THE UNCERTAINTIES SURROUNDING our understanding of interactions between the ocean, the atmosphere and the biosphere can be solved by testing today's models using data from the Earth's geological past. Conditions in the atmosphere change much more rapidly than those in the ocean, and they both alter in response to each another.

Future global models will represent land surface processes and their feedback to the atmosphere much better than today's models. This improvement will help us to understand how biosphere processes influence the earth system. Imperial is working to integrate its strengths in biology, hydrology, meteorology and earth observation to improve global models.

Testing carbon cycle models

Professor Colin Prentice is the Grantham Institute's Professor of Climate and Biosphere Interactions. He is keen on Grantham's multidisciplinary approach: "It is essential to work in this way to overcome the credibility problems that you get when everyone works in their own paradigm." Professor Prentice is developing a novel model of the terrestrial carbon cycle, "from the individual leaf to the entire globe".

The model is being tested in two ways: by comparing it with data from satellites, atmospheric measurements and other sources; and by seeing how it performs with data from earlier periods such as the Last Glacial Maximum, 21,000 years ago, when the Earth's climate was very different. The model shows that the lower levels of biological activity at that time are closely related to the lower levels of atmospheric carbon dioxide, which we can measure directly from ice cores.



The seasonal timing of maximum fire, indicating burnt areas, as simulated by the Land Processes and Exchanges (LPX) global model (top) and as seen from space (bottom). Fire is a source of many important trace gases, as well as a hazard. (Courtesy of Douglas Kelly and colleagues)

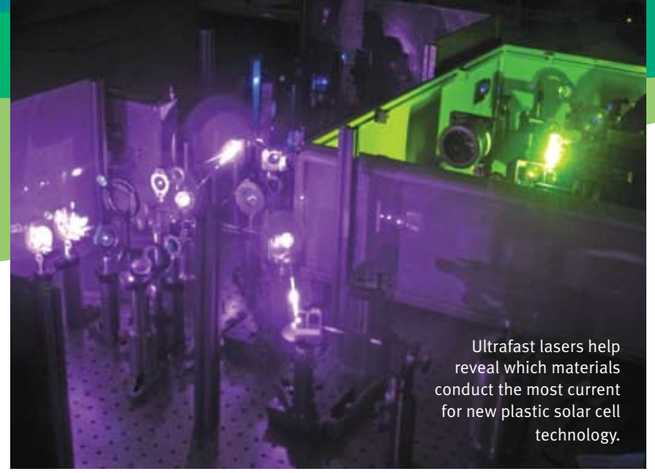
The terrestrial biosphere holds three times as much carbon as the Earth's atmosphere, so models using the data available on the interaction between the two systems are essential. Professor Prentice's work also considers other greenhouse gases such as methane, much of which comes from single-celled archaea, which thrive in wet soils and bogs, and are likely to get more active as the climate warms. He is also studying isoprene, the precursor to ozone, which is given off by plants in increasing amounts as temperature rises. In the lower atmosphere ozone is a powerful greenhouse gas, a serious pollutant and key contributor to low air quality.

Understanding currents

PhD student Alistair McVicar is based at Imperial's Department of Earth Sciences and Engineering. An oceanographer and computer modeller, his PhD is concerned with a big change to the Earth's oceans in the geological past. He is looking at the opening of the Drake Passage between South America and Antarctica, which occurred 34 million years ago causing the formation of the Antarctic Circumpolar Current (ACC), which circulates non-stop around the Southern Ocean. This may be the event that caused the Antarctic to become glaciated — one of the biggest-ever changes to the Earth's environment.

McVicar says: "Our ability to understand major changes in the Earth's history validates our models and lets us see how the Earth behaves. We know that the ACC pushes surface water north, but we are less clear about the mechanism that returns it southwards. This is a unique feature of the ACC, as most other currents, such as the Gulf Stream, reverse when they hit land. But the ACC never meets a landmass. The model we have developed, called the Imperial College Ocean Model (ICOM), allows us to model the small ocean eddies that we believe are responsible for this important feature of the ACC."

Above: Alistair McVicar demonstrates an ICOM simulation of the flow dynamics past a cylinder, which mimics the flow around geological features on the Southern Ocean floor.



Ultrafast lasers help reveal which materials conduct the most current for new plastic solar cell technology.

Plastic solar cells

PhD student Luke Reynolds is approaching the problem from a Chemistry perspective, by exploring the use of semiconducting plastics instead of silicon for photovoltaic cells.

Plastics cost less money and use less energy in their manufacture than silicon, and the technology is relatively accessible: if a country has the technology to make a plastic bag, it should be able to make a plastic solar cell. Such technology would be ideally suited to providing electricity on a large scale in the developing world. At the moment, however, the highest efficiency it has reached anywhere in the world is 8 per cent.

The reasons for low efficiency are not clear. Reynolds is using ultra-fast lasers to discover which materials give more current for a given amount of light absorbed. Knowing which materials are best suited to the technology would indicate whether performance is low because of an inherent limit to its efficiency, or because current materials need improvement. Either way, the answer would help us understand what the real contribution of plastic cells might be.

Nano-structured solar cells convert solar energy to electricity more than twice as efficiently as existing technology.

Renewable technologies

AS PART OF ITS WORK TO MITIGATE THE EFFECTS of climate change, the Grantham Institute is seeking to catalyse a transition to a low-carbon economy by building on ongoing research at Imperial to develop new technologies, such as better ways to harness solar power.

Sunlight provides the energy that powers the Earth's climate and ecosystem. Using it to produce hot water and electrical power could provide a renewable, low-carbon energy source. In developing countries, solar technologies are already in use to raise the standard of living. They are a natural choice where solar influx is high and grid electricity is unavailable or limited.

In developed countries, solar energy can seem less attractive than conventional sources due to its intermittent nature. With the right technology, however, it can bring considerable benefits in terms of reduced carbon emissions and improved energy security. Most forms of solar energy are at present more expensive than conventional alternatives, although in some favourable locations it may soon come down to the residential grid price. At this pre-competitive stage, incentives are needed to encourage their uptake.

Nanotechnology and solar panels

The law of diminishing gains means that current semiconductor solar panel technology will run out of improvements in 10-15 years. So researchers in Dr Ned Ekins-Daukes' group in Imperial's Department of Physics are taking a fundamentally different approach to photovoltaic technology. By building on basic thermodynamic principles, they aim to increase solar panel efficiency from the current maximum of 30 per cent towards the theoretical maximum of 86.8 per cent.

One possibility is to increase the spectrum of light available to the panel. The research group has demonstrated the feasibility of making a panel with an extra layer that absorbs low-energy photons, which normally pass through solar panels, and re-radiates them at a higher energy, which the panel can absorb. In theory, this can raise efficiency from 30 to 49 per cent.

Nanotechnology enables improvements in solar cell efficiency to be made by broadening the spectrum of light that solar panels can absorb. Last year in partnership with Imperial spin-out company, Quantasol, Dr Ekins-Daukes' group set the world record for the most efficient nano-solar cell. "We aim to increase efficiency and reduce costs," he says.

Carbon capture and storage

THE GRANTHAM INSTITUTE IS SEEKING TO DEVELOP clean technologies for large-scale power generation, and is working with Imperial researchers to capture CO_2 released from power stations. Finding safe ways of storing the CO_2 underground could remove it from the atmosphere altogether. Imperial is a lead organisation in the UK Carbon Capture and Storage Consortium.

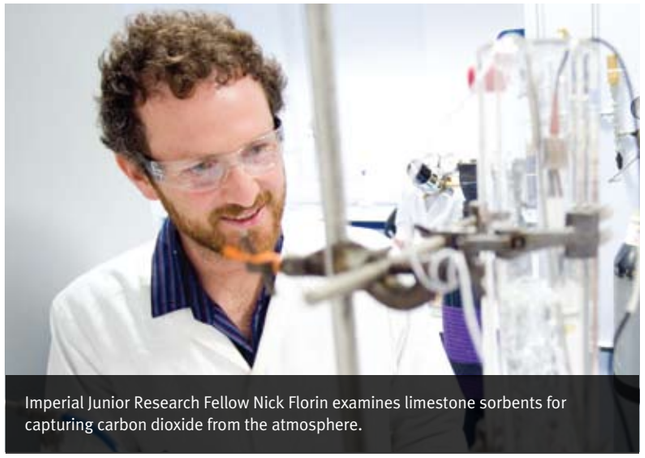
Carbon capture and storage (CCS) gets to the root of climate change by producing carbon-free forms of energy. Advanced CCS technologies will be used in power stations, and to produce hydrogen for fuel cells and energy for heavy industry such as cement, steel, oil and gas. Costs still need to be reduced, but CCS is widely seen as the most promising technology to promote climate-friendly development in some of the world's rapidly growing economies.

Carbon capture technologies

Dr Nick Florin is working on one promising CCS technology - carbonate looping. This captures CO_2 by using a solid sorbent derived from limestone. This is essentially a purification process: CO_2 makes up only about 15 per cent by volume of coal-fired power station exhaust gas, and a pure stream of CO_2 is needed for transport, storage and other industrial processes.

Carbonate looping is a more effective process than other technology currently being developed, but the limestone sorbent degrades with time. At his lab bench, Dr Florin is experimenting with improving the process by tailoring synthetic sorbents to minimise the drop-off in their capacity to capture CO_2. His results so far are, he says, "very promising", with the synthetic sorbents capturing about three times more CO_2 per gram of sorbent than natural limestone.

As the new recipient of an Imperial Junior Research Fellowship, Dr Florin is looking forward to being able to focus on his research for the next three years. He has already advised the Environment Agency for England and Wales about CCS technologies, and is keen to become more involved in bringing science to the policy table.



Imperial Junior Research Fellow Nick Florin examines limestone sorbents for capturing carbon dioxide from the atmosphere.

Maximising carbon storage

The North Sea, with its mature hydrocarbon fields and saline aquifers, is an attractive place to store CO_2 produced by the UK's gas and coal-fired power plants. Earth Sciences and Engineering PhD student Ana Mijic is working on modelling the factors that affect the injection rate of CO_2 into the subsurface. "I am working on an analytical solution, which means you don't need any big computational effort," says Mijic.

Mijic's work addresses parameters that affect the efficiency of aquifers as CO_2 stores. When CO_2 is pumped in at high temperature and pressure, the aquifer may fracture. Alternatively, the aquifer water can evaporate, precipitating the salt, which clogs up the pores in the aquifer's rock, leaving less room than predicted to store CO_2. Mijic's research uses advanced mathematical methods to design injection to avoid these problems, ensuring secure and efficient storage.

Above: Grantham PhD student Ana Mijic is working on reducing CO_2 emissions from power stations to the atmosphere by developing more accurate ways of predicting the rate at which the gas can be stored in the subsurface.

Susceptibility to climate change

Maria Dickinson is a Grantham PhD student working on the susceptibility of species to climate change. The idea of biological susceptibility to climate change is a new one. In the past, a species was regarded as vulnerable if its physical range were to shrink under climate change. But we now know that there can be other, intrinsic factors that make some species more susceptible to changing conditions.
She says: “An obvious factor is reproductive capacity. For example, the cane toad (*Rhinella marina*) produces about 12,500 eggs in an average clutch, while other amphibians might lay only 10. That sort of difference needs to be built into future models.”

Dickinson’s PhD grows out of work carried out by the International Union for the Conservation of Nature, which produces the Red List of threatened species, and which has become increasingly aware that climate change affects vulnerability. Her work will help to identify species at highest risk and design mitigation strategies for endangered species. She is developing a frog population model to see what happens, for example, when climate change alters rainfall.

She says: “Our research will allow us to see how important these factors are, and will help set guidelines for conservation bodies.”

Above: The corroborree frog, *Pseudophryne corroboree*, has been known to lay as few as 10 eggs in a clutch, making it potentially susceptible to changes in climate.

Biodiversity

WITH SUPPORT FROM THE GRANTHAM INSTITUTE, Imperial researchers are harnessing climate modelling techniques to track the shifting patterns of land use and urbanisation on different species and conservation areas. They are also mapping possible future trouble spots, helping policy makers to anticipate tomorrow’s conservation needs.

This research is revealing evidence for the accelerating impact of climate change. Loss of biodiversity can have an especially harsh impact in the developing world, where ecological functions are often closely linked with basic human needs, and it is here that Grantham research has particular relevance for policy-makers.

Deforestation and extinctions

Life scientist Dr Rob Ewers says that the Grantham Institute has enabled him to learn from a wider range of professional colleagues, such as hydrologists, whose work is important to his thinking and whom he might never have encountered in a conventional university setting.

Dr Ewers’ focus is on tropical forests, and what happens when they are cleared. He is setting up what may be the world’s biggest ecological experiment, working with the Malaysian state body responsible for developing the Sabah region. “The Sabah Foundation is converting 100,000 hectares of forest to oil palm. We have convinced them to leave behind a number of forest patches of different sizes so we can see how these isolated ecosystems change over time. We think that it will take about 10 years for some species such as beetles to become extinct even in a single hectare of uncleared land. It might take decades for extinctions to begin in a 100 hectare island of forest.”

The experiment will track water and sediment flows in small streams as well as carbon exchanges with the atmosphere. Dr Ewers says: “At the moment, nobody knows exactly how much carbon is released when deforestation occurs and over what period, but tropical deforestation does seem to account for 15-20 per cent of human carbon emissions.”

A large-scale ecological experiment in the tropical forests of Malaysia will reveal the effects of deforestation on human carbon emissions and species extinctions.

CREDIT (top left): National Geographic/Getty Images

Ecosystem services

ECOSYSTEMS ARE UNDER STRESS, and the costs tend to be borne by the world’s poorest and most vulnerable people. Their societies are already dependent on degraded ecosystems, and will often be the first to bear the impacts of climate change.

Understanding these pressures, and their likely consequences for ecosystems and people, is a priority for the Grantham Institute. This work will improve sustainable management plans and policies.

Conservation and public health

Dr Blake Suttle, Grantham Lecturer in Global Change Biology, says that he approaches his research in new ways as a result of the Grantham approach: “We can have people with a background in policy or economics, or physics or chemistry, in the same room, and when you work this way you soon start to see the benefits for your own understanding.”

Blake Suttle uses his rainfall simulation experiment in California to teach students about climate change.

Dr Suttle’s research is on community ecology—the interactions between species. He is challenging the assumption that climate change mostly affects species directly, by exploring how species might interact differently as global warming takes its course. He is especially interested in predictability: “There are so many species involved in these interactions, we have to get some idea of what is important and what we can ignore”.

His own work has centred on an experiment in California in which he uses machines built to spray golf courses to simulate rainfall patterns expected under climate change. This suggests complex challenges for predicting impacts, but relatively simple rules for managing them.

Whether our concern is agricultural yields, biodiversity, or disease, understanding the interactions among species is critical to mitigating future climate change impacts. Malaria is a prime example: changing climate will affect the parasite, the mosquitoes that vector the parasite, and humans as ultimate hosts of the disease. These effects will interact in complex ways.

Results from modest and tractable creatures such as spiders will inform our understanding of how a wide range of more complex species may respond to climate change. Humans are at the very top of a long food chain: “This research will help guide agricultural practice for the next 50 years. We depend on many other species. We need to know how they’re going to be affected by climate change so we can plan our own responses.”

Public health

Water is a central issue for the Grantham Institute, which funds PhD student Aneire Khan from the Department of Epidemiology and Biostatistics to examine a significant health hazard caused by the effects of climate change on water supply in Bangladesh.

Khan’s research is on salt water intrusion from the Bay of Bengal, which is polluting water supplies in the coastal region of Bangladesh. This problem has affected 20 million of the region’s 40 million people. Khan’s main interest is pregnant women, who are especially at risk from saline drinking water. She is attempting to test a possible link between their intake of salt and the incidence of hypertension and pre-eclampsia amongst pregnant women—hazards to the women and their babies.

The salt hazard is especially marked in the dry season from October to April, and less severe between June and September when rainwater displaces briny water from the sea. Khan’s work may point towards interventions such as increased capture of rainwater or more household water storage. In addition, she says that few women in Bangladesh seek medical help when they give birth. Women in her study who have high blood pressure are given free hospital treatment.

Predicting local rainfall

Another set of data for this research will be provided by hydrologist and PhD student Juan Duan, who is working on statistical models of drought in south eastern England under various conditions of climate change.

Duan is developing methods to use large-scale atmospheric variables, such as temperature and pressure, to predict rainfall at local and regional scales. From this, she aims to determine the effects that future climate will have on extreme drought in south-east England. By checking whether the model would have predicted the worst droughts to have been observed since 1870, and making sure it is consistent with the physics of climate change, she aims to use the model to make predictions of rainfall statistics up to 100 years into the future.

If Duan is successful, other PhD students in the group can use the rainfall values, together with other variables such as evaporation, to model water run-off into aquifers and to assess the scope for water transfers, and hence support long-term water resources planning.

Above: Better predictions of local rainfall will improve our preparation for future climate change in south-east England.

The water cycle

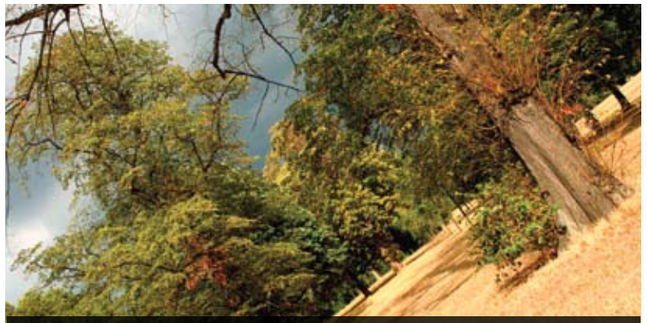
A WARMER CLIMATE WILL INCREASE EVAPORATION and the intensity of water cycling, and result in greater amounts of moisture in the air. We do not know for sure how water cycles will change, but the likelihood is that extremes will become more extreme, with many dry regions becoming drier and wet regions getting wetter. Hydrological extremes such as droughts and floods will probably become more frequent and severe. This is a major concern for planning in most parts of the world.

The Grantham Institute is bringing together our world-leading meteorological, statistical modelling and hydrological communities to develop better ways of predicting how flooding and water resources will be affected by climate change. Our researchers aim to improve the estimation of variables such as rainfall relevant to future water management, and to use this data to estimate future hydrological variability to support impact assessment.

Regional water strategy

Dr Neil McIntyre and the hydrology research group are researching the science that will underpin a long-term strategy for using water in London and the south east of England (one of the water-stressed regions of the world). The strategy will answer questions such as: Will the severe historical droughts observed about 100 years ago become more likely in future? How bad may they be? How many new reservoirs are needed and where should they be built? How much reliance can be placed on groundwater? Would it be worth transferring water from the Severn to the Thames and then to south east England?

Current models of climate change do not produce enough information at regional geographical scales, so one part of the research is to turn outputs from global climate models into data that can be used for regional plans.



After a long hot summer, London's Hyde Park shows why south east England needs a better way of preserving and protecting future water supplies.

Predicting and managing risks

CLIMATE CHANGE IS A MULTI-FACETED PROBLEM, which needs CROSS-disciplinary research to produce useful results. The Grantham Institute has brought together a multidisciplinary cadre of researchers to improve our preparedness for extreme climatic events.

Changing temperatures can bring other change with them, such as unusual rainfall patterns, increased drought and flood risks, and more frequent cyclones in different parts of the world. The devastating impact of Hurricanes Katrina and Rita in 2005 demonstrates the risks that could become more common with extreme climatic events. 2005 saw weather-related catastrophe losses total almost $80 billion worldwide. In that year, 99.7 per cent of all catastrophe losses were weather-related. A key sector likely to be impacted is the insurance industry, which may be buffeted from both sides by climate change. Assets may fall in value suddenly if climate-related impacts occur, and liabilities may also rise. Assessing the impact of the risks associated with climate change is therefore a key priority.

The insurance industry has traditionally relied on historical calculations of risk when drawing up policies. However, climate change means that some extreme events may occur more frequently than in the past. Another crucial difference is that they may not occur independently of each other: where there is one hurricane or flood, it may be more likely that another one will follow. In this new situation, insurance companies have sustained such high losses from extreme events that they have withdrawn altogether from some markets—a businessman wanting to set up a hire boat firm in the Gulf of Mexico can no longer buy insurance.

Assessing and spreading risk

To enable the industry to maximise capacity, it needs to make more realistic forecasts. Dr Walter Distaso, a Reader in financial econometrics at the Imperial College Business School, is incorporating new weather forecasting into the industry's old catastrophe models. His research group is also seeking ways of spreading risk more efficiently, possibly by allowing policy renegotiation every year on a more reliable basis. Another option would be to explore a role for a central body, perhaps involving government and regulators as well as the industry, to share extreme risks.

Helping the insurance industry make more realistic forecasts will improve its previous catastrophe models.

Forecasting extreme events

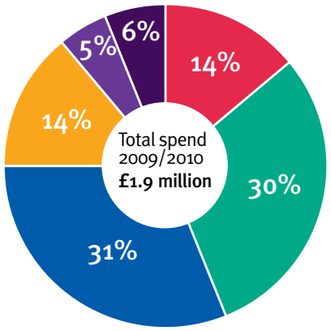
PhD student Erica Thompson's research is also focused on helping insurance companies. As a physicist and mathematician, she is analysing climate models for more physical insights into extreme events than the usual statistical methods can provide. Knowing the physical parameters of these events will help in forecasting whether they will become more frequent or severe. And knowing that, she will be able to forecast how the risk will change. This is useful not only for insurance but also for decisions about adaptation, for example on whether to build defences against storm surges in the North Atlantic.

Thompson is funded by the UK Met Office as well as the Grantham Institute. At the moment she is analysing patterns in the atmosphere to see whether certain background conditions are likely to produce more extreme events, for example whether the influence of the jet stream and other atmospheric conditions will make winter storms in Europe more likely. Later in her project, she will move to translating her findings into better measures of risk. "I started this PhD because I wanted to do something useful for society," says Thompson. "Policy needs to be informed by real science or we'll make the wrong decisions."

Above: Understanding the physical parameters of extreme weather events will improve our ability to work out if they are going to become more frequent or more severe.

The Grantham Institute for Climate Change has five key goals:

- Climate change **leadership** and coordination at Imperial College London
- Funding and delivery of **research**
- **Education** to develop the next generation of climate researchers
- Influencing **policy** and providing advice
- Communication and **outreach**



Breakdown of Grantham Institute goals by expenditure

Leadership
Research
Education
Policy
Outreach
Institute running costs

Become part of the Grantham community

At the Grantham Institute, we build on the existing multidisciplinary research expertise at Imperial by fostering a broad community of funders, sponsors and partners from private and public sectors. Our multi-million pound founding donation from the Grantham Foundation for the Protection of the Environment has enabled us to build a series of creative partnerships. These help us develop essential research, advice and engagement to generate and discuss solutions to the urgent problems posed by a changing climate – we are always keen to expand our partnership base.

In the past 12 months, we are pleased to have set up a number of private sector research collaborations with organisations such as the food retail chain Sainsbury's and long-term savings group Old Mutual. We have also become involved with a number of public research collaborations, and remain grateful for continued research support from the public sector, including the Research Councils UK and the European Institute of Innovation and Technology.

These more recent collaborations build on the strong partnerships we have already established with other world-leading institutions for climate-related research. In particular, we enjoy close relations with two other institutes also funded by the Grantham Foundation. The first is with the Grantham Research Institute on Climate Change and the Environment, based at the LSE. This is led by Lord Nicholas Stern, and our work is formally integrated through a joint Advisory Board and cross-representation on each other's Management Boards.

The second is with the Divecha Centre for Climate Change at the Indian Institute of Science in Bangalore, where a top priority has been collaborating on understanding the impacts and risks associated with climate change and the changing water cycle. With partners at the University of Reading, we are developing joint work about the Indian monsoon, its impacts on ground and surface water, and implications for managing water resources in the future. We also enjoy opportunities to broaden our community through our active and international outreach programme of lectures, events and media relations. Recent collaborations with the Science Museum, the British Council and the Royal Society have helped us address the need for early action with students and general public audiences.

As you will have seen from this report, the Grantham Institute has a flexible approach to establishing partnerships, which vary in scale, duration and scope to enable diverse organisations to come together in different ways. We always welcome the opportunity to build new partnerships, which can be from something as simple as attending an event, through to supporting a scholarship or sponsoring a research programme. To find out more about the different ways in which you can be involved with us, please contact us on grantham@imperial.ac.uk.

Research partnership: Grantham Research Associate Mirabelle Muûls works closely with colleagues at LSE (and Carlos III University of Madrid) to improve our understanding of why some firms use ten times more energy than others, yet still produce the same value of similar goods.

Muûls is funded by the European Climate Foundation and is currently researching energy efficiency in companies from manufacturing sectors that include textiles, metals, chemicals and pharmaceuticals. Her work will underpin the new phase of the EU Emissions Trading Scheme (EUETS), which comes into force in 2012. This phase will classify firms according to whether they will be issued with their carbon trading permits for free (as at present) or whether they will have to buy them at auction.

Muûls' research will tease out how to classify firms on a more nuanced basis than the EU's present criteria, which are based on the amount of carbon that firms emit and the extent to which their sector trades with other countries. This would address the current vulnerability of some places to competition from countries with less stringent climate change policies.

Research consortium: The Avoiding Dangerous Climate Change programme provides advice to government on achieving emission limits to avoid the most critical impacts of climate change. It is led by the Met Office in consortium with the Grantham Institute, the Walker Institute for Climate System Research and the Tyndall Centre for Climate Change Research.

Private sector partnership: Imperial and Sainsbury's celebrate the launch of their five-year partnership to help the retail consumer sector reduce its carbon footprint by exploring options for future stores to take advantage of smart grid technology, and to provide energy to customers. From L to R: Professor Sir Brian Hoskins, Neil Sachdev, Sainsbury's Commercial Director, John Ashford, Sainsbury's Head of Engineering and Nilay Shah, Imperial's Professor of Systems Engineering.

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 http://www3.imperial.ac.uk/climatechange/news

Climate media briefings

Professor Brian Hoskins is a regular speaker at Science Media Centre briefings for news journalists, helping to raise the profile of the scientific community in public climate change discussions. 2009-2010

smc Science Media Centre
where science meets the headlines

Climate change traps African birds

Research published by Grantham PhD student Lynsey McInnes on how African birds respond to climate change in *Proc Royal Soc B* is covered by media outlets including Asian news international. June 2009

Shrinking sheep

Professor Tim Coulson's research in *Science Express* on why Scotland's Soay sheep are getting smaller makes headlines around the world. July 2009


It's been blamed for a lot of things, but now global warming is shrinking sheep

Adaption costs more than thought

Media report widely on the Grantham / IIED report in which Professor Martin Parry warns that we need to budget for more to protect societies from climate change. August 2009


Annual cost of climate change 'will be £190bn'

Talking straight

Professor Sir Brian Hoskins talks to *The Economist* about what the uncertainties of climate science mean for policy makers, and the relationship between the media and climate scientists. March 2010

Storage capacity

The Guardian publishes an article by Imperial's Head of Earth Sciences and Engineering Department Professor Martin Blunt on how carbon capture and storage can stall the effects of climate change. May 2010

theguardian

Grantham Institute for Climate Change

The Grantham Institute is committed to driving climate change related research and translating it into real world impact. Established in February 2007 with a £12.8 million donation over ten years from the Grantham Foundation for the Protection of the Environment, the Institute's researchers are developing both the fundamental scientific understanding of climate change, and the mitigation and adaptation responses to it. The research, policy and outreach work that the Institute carries out is based on, and backed up by, the leading edge research of academic staff at Imperial College London.

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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 one million people each month.