

Spring/Summer 2018

# Planet Earth

NERC is part of UK Research and Innovation – [nerc.ukri.org](http://nerc.ukri.org)



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### Come to **Operation Earth**

You probably already know lots about climate change, but there are lots of other environmental challenges facing our planet. This issue of *Planet Earth* explores some of the amazing science that NERC researchers are doing here in the UK and with colleagues around the world to learn about and tackle them.

*Operation Earth* is a great way for you to learn about these challenges and tackle them too. Through *Operation Earth* you can also find out ways of getting involved in citizen science projects investigating these challenges and you'll get to talk about things you can do at home to reduce your impact on the environment.

So, come to *Operation Earth*, explore the challenges and help find solutions for our world!

Find out more at  
[www.operationearth.co.uk](http://www.operationearth.co.uk)

**Dr James Pope**  
*Climate modeller and polar scientist at  
British Antarctic Survey*

Last Autumn, BBC's *Blue Planet 2* captured public interest with impressive footage of life in our oceans. The programme featured a wealth of NERC-funded science and scientists including an interview with Dr Lucy Quinn, based at British Antarctic Survey. In a memorable moment, Lucy turned out a container full of plastic items that albatross chicks had eaten, sometimes with fatal consequences.

Since the programme aired, interest in reducing plastic waste has been high and that interest could help to turn the tide. This effect demonstrates the importance of talking about environmental science and that is why I am so pleased that our show *Operation Earth* is now on at science centres across the UK.

*Operation Earth* gives families with children aged 6 to 11 the chance to find out more about NERC funded environmental science. In doing so they will also be able to help find the solutions to challenges our planet faces.

Environmental science is so important not just because researchers like Lucy are out documenting problems, but because they are finding the solutions. For example, in January 2018 microbeads were banned from many products on sale in the UK, partly thanks to evidence from

many of our researchers that informed recommendations by the House of Commons Environmental Audit Committee.



We have a proud history of these success stories, of science that led to the world cutting the pollutants causing acid rain and the hole in the ozone layer. Of science that enables us to predict floods further in advance and that means clean energy developments can go ahead safely.

Scientific discoveries and advances are almost never made by one person acting alone. They come from years of work involving different people, teams, countries and disciplines. NERC has recently become part of a new organisation – UK Research and Innovation – that will bring together the different research councils into a single organisation that aims to ensure the UK maintains its world-leading position in research and innovation.

The environment and the climate have changed constantly throughout the history of the Earth. However, never before have they changed so much and so quickly as in the last 150 years. Working with the rest of the disciplines in UK Research and Innovation, environmental science can provide us with the evidence for the solutions we need to not just keep pace with these changes, but outrun them.

**Professor Duncan Wingham**  
*Executive Chair of NERC,  
part of UK Research and Innovation*

### NERC becomes part of UK Research and Innovation

Operating across the whole of the UK with a combined budget of more than £6 billion, from April 2018 UK Research and Innovation will bring together the seven Research Councils, Innovate UK and a new organisation, Research England. UK Research and Innovation will ensure that the UK maintains our world-leading research and innovation position by creating a system that maximises the contribution of each of the component parts and creates the best environment for research and innovation to flourish.

Read more: [www.ukri.org](http://www.ukri.org)

**UK Research  
and Innovation**

## Cutting-edge science enables better weather forecasting

Analysis in our 2017 Impact Report shows NERC science is key to the delivery of an estimated £680 million of annual benefits through its role in enabling the Met Office to provide a world-leading weather and climate service. The benefits from the improved predictions include:

- 23 lives saved each year in construction sector
- £120 million a year saved by improved aircraft routing
- up to £100 million a year saved by reductions in flood damage.

Professor Stephen Belcher, Met Office Chief Scientist, is quoted in the report:

*“Our research relationship with NERC is vital for the Met Office. It ensures that we can continue to produce world-leading science to support the advice and services we provide to our stakeholders and customers.”*

Read more about the different impacts of NERC science: <http://bit.ly/NERCImpactReport17>



## Crucial upgrade to UK environmental science supercomputer

A major upgrade is being made to double the storage available in the UK's leading environmental science supercomputer, JASMIN. The upgraded system will support the global analysis of the next generation of climate models and provide a venue for UK academia and industry to use Earth observation data.

Read more: <http://bit.ly/JASMIN4>

## Lightning storms less likely in a warming planet, study suggests

Scientists from the Universities of Edinburgh and Leeds and Lancaster University used a newly devised method to calculate the likely incidence of lightning flashes from storm clouds.

They have forecasted a 15% drop in the average number of lightning flashes worldwide by the turn of this century, if global temperatures are in the top range of forecasts.

Read more: <http://bit.ly/2ISUUBb>

## Air quality research supersites set for Manchester, Birmingham and London

A new network of advanced air quality monitoring instruments will detect harmful air pollutants and their sources in greater detail than ever before at existing research sites in three UK cities.

The urban air pollution research laboratories, or 'supersites', are expected to be operational in London, Birmingham and Manchester by the end of 2018. The new equipment will allow researchers to gather higher-quality data on the content of harmful urban air pollution and where it comes from.

Funded by NERC, the £4.3 million investment will see eight universities led by the NERC Centre for Atmospheric Science (NCAS) set up and run the new equipment. As well as sensors to detect toxic air pollutants, the investment will include new instruments to detect a variety of greenhouse gases and ozone-depleting chemicals, at a range of UK tall tower and coastal observatories run by the universities of Bristol, East Anglia and Edinburgh, and so help the UK also comply with legally-binding targets set out in the Climate Change Act.

Read more: <https://nerc.ukri.org/press/releases/2018/02-air/>

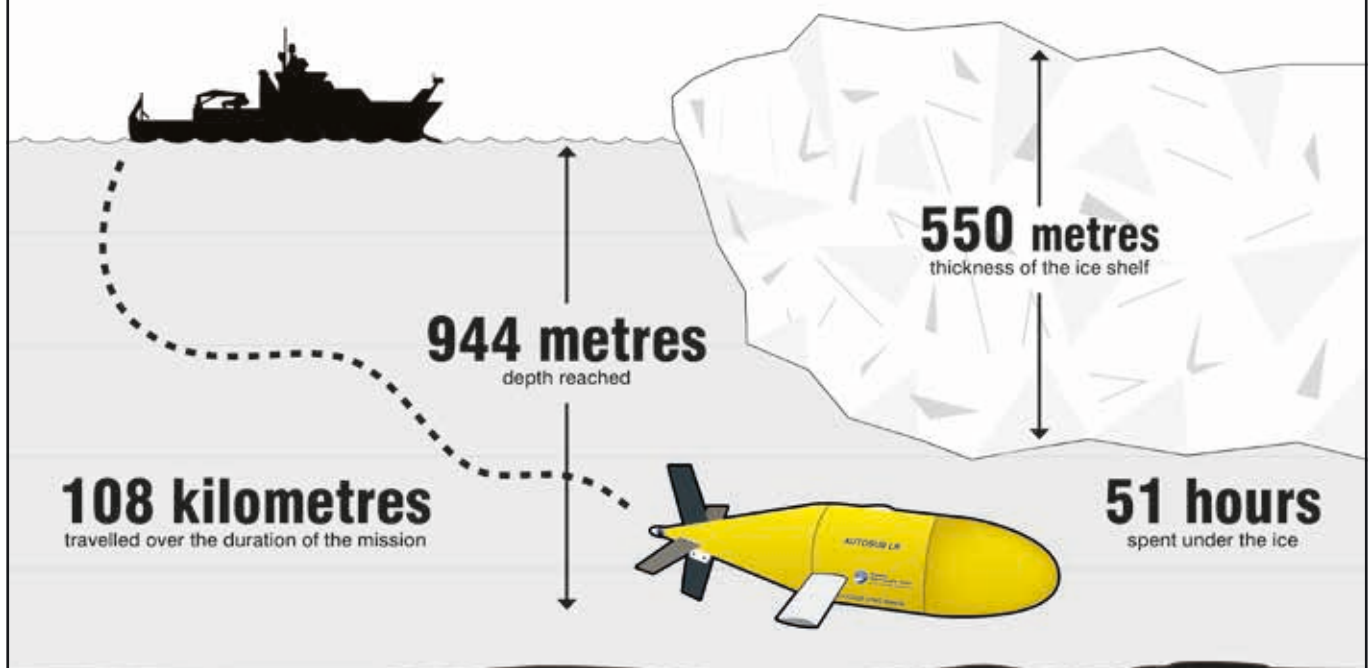




## Boaty returns from first mission under the ice

The yellow high-tech autonomous underwater vehicle, affectionately known as Boaty McBoatface, has successfully returned from an ambitious science expedition deep below half a kilometre of ice. It is the first time that Boaty has been deployed underneath an ice shelf, demonstrating the important contribution that technology is making to help scientists understand what happens in hostile and otherwise inaccessible parts of the ocean.

Read more: <http://bit.ly/AntarcticBoatyl>



### Autosub Long Range (ALR) specification:

**Length:** 3.6 m  
**Width:** 1.5 m (including wings)  
**Mass:** 600 kg  
**Running Speed:** 0.5 m/s to 1.0 m/s  
**Maximum depth:** 6000 m

**Endurance:** 1000 km, 20 days (with 20% contingency and primary batteries)

**Communications:** Iridium (worldwide); Wi-Fi (at a range of 1 km to base station).

**Sensors:** For this mission the vehicle was fitted with an upward and downward looking ADCP (Acoustic Doppler Current Profiler), 2 CTD (Conductivity, Temperature and Depth) sensors, a chlorophyll fluorescence sensor, turbidity sensor, and a turbulence micro-structure probe.



## Warming seas could put at-risk seabirds out of sync with prey



Seabirds may struggle to find food for their chicks as they are unable to shift their breeding seasons as the climate warms, a study suggests.

Rising sea temperatures in coming decades could create a mismatch between breeding periods and times when prey is most plentiful, researchers say.

A team from the University of Edinburgh, the Centre for Ecology & Hydrology and British Antarctic Survey studied data on the breeding patterns of 62 seabird species between 1952 and 2016, as sea surface temperatures rose sharply.

They found that seabirds have not altered their breeding times in response to rising temperatures. Previous research has shown however that climate change has brought forward when many prey species – including squid, shrimp and small fish – reproduce.

The findings suggest that if prey species continue to shift their breeding seasons forward – as previous studies have shown in some regions – it could further threaten the survival of vulnerable seabirds such as puffins and albatrosses.

Seabirds have much longer lifespans than their prey and do not reproduce until they are a few years old, which means it takes them many more generations to adapt, researchers say.

Read more: [www.ed.ac.uk/biology/news-events/news-2018/](http://www.ed.ac.uk/biology/news-events/news-2018/)

Herschel Hofmeyer



Palaeontologists investigate the macabre science behind how animals decay and fossilise.

## The curse of zombie fossils

A key part of palaeontological research involves reconstructing long-extinct creatures to understand what they were like when they were alive.

This knowledge allows us to answer fundamental questions – how did they move and interact with their environment? How did they feed and reproduce? Which of today's organisms are they most like and most closely related to?

A group of palaeontologists from the UK and Ireland, led by the University of Leicester, have followed a macabre, and nasally-challenging road to knowledge – watching carefully as animal carcasses decompose in order to better understand the process.

Fossils preserve only incomplete remains of the living body. Understanding how much of a fossil is missing, and what has been changed by decay and fossilisation, helps to create a more accurate picture of ancient animals and ecosystems.

Read more: <http://bit.ly/zombiefossils>

## UK and USA join forces to understand how quickly a massive Antarctic glacier could collapse



Scientists are due to begin the most detailed study of a massive Antarctic glacier ever undertaken.

As part of a new £20 million research programme, the U.S. National Science Foundation and the UK Natural Environment Research Council have jointly funded eight large-scale projects that bring together leading polar scientists in one of the most inhospitable regions of the planet.

See the graphic in our centre spread for more information and read more: [www.nerc.ukri.org](http://www.nerc.ukri.org)

## Predicting deadly landslides with WhatsApp

Researchers are using WhatsApp to help predict deadly landslides in Colombia by training a local community to monitor how their hillside is shifting over time.

The multi-skilled team is working with the community in an informal settlement in Medellin City, which is perched at the top of a high slope. They have been teaching the local residents how to identify early warning signs of a landslide, which could devastate their community and similar neighbourhoods along the hillside.

The residents take regular photographs at set points from carefully mapped angles during and after periods of rain. Using Whatsapp is important as it records the time and date automatically and it's globally accessible. These photographs allow researchers to see early signs of movement.

The initial project is funded by the Global Challenges Research Fund through NERC, with additional funding now secured through the Global Challenges Research Fund to roll out the model to two more communities in Medellin City in 2018. The team includes researchers from Heriot-Watt University, the University of Edinburgh and the National University of Colombia.

Read more: <http://bit.ly/2136Cbg>

Medellin's steep hillside homes are vulnerable to landslides.



# On the way to plastic-free oceans

Written by Sylvie Krainiger



Microbeads were banned from a number of UK products in January 2018.



680 tonnes of plastic microbeads were used in the UK every year.

There are trillions of pieces of microplastic in the oceans.



Microplastics from cosmetic products used in a single shower could result in 100,000 plastic particles entering the sewage system.

Four days since leaving port, Dr Katsiaryna Pabortsava reaches her destination. She's in the middle of the North Atlantic, thousands of miles from land, and she's looking for microplastics.

Microplastics are tiny fragments of plastic often too small to see with the naked eye.

She said. "You might think that out here in the middle of the ocean we would see pristine waters but the Atlantic currents act like a huge whirlpool, drawing everything in from the coasts. So, sadly, there's plenty of plastic here."

She and her team are taking samples from this and another site in the South Atlantic Ocean. They're scooping them from the top layer of the sea bed and at different depths of the water above it.

"At the moment we don't know how much microplastic pollution there is, we don't know how it behaves and we don't know how it affects sea life. Until we can find some answers to those questions, we're going to struggle to find solutions."

## Useful little things

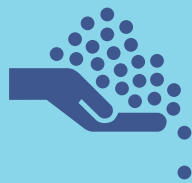
From 2018, the UK government has banned one source of this pollution – called microbeads – from lots of everyday products. Microbeads are often in things like facewash and toothpaste. They exfoliate, they don't cause allergic reactions and they can break open to release an ingredient at a specific moment.





Most microplastics come from bigger items – many of them only used once.

## What can I do?



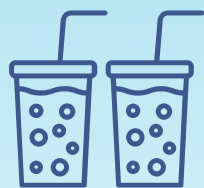
### Join the great nurdle hunt

Look out for these tiny, lentil-sized plastics on beaches and report your sightings. [www.nurdlehunt.org.uk](http://www.nurdlehunt.org.uk)



### Two minute beach clean

You don't even need to be by the coast – litter picking anywhere will help to stop some plastics going into the environment. <https://beachclean.net/>



### Use less plastic

Avoid items that contain microbeads and single use plastics like drinking straws. Take your own cup when you buy a takeaway coffee.

The trouble with these useful little beads is they're so small they slip through filters at sewage works and out into the oceans. They can get eaten by microscopic plankton and travel up the food chain into fish and, eventually, us. We don't know what affect that might have on animals yet and scientists are working hard to find out.

Since scientists began to understand more about microplastics pollution in the oceans they've been working with government and businesses to stop more plastics from getting into the sea. As a result, lots of soap companies have been phasing microbeads out of a lot of their products in time for the ban, including big names like Unilever, Johnson & Johnson and Procter & Gamble. The ban will not apply to products that you leave on your skin such as sunscreen and make-up.

### The bigger plastics picture

Katsiaryna says: "The microbead ban is a wonderful step forward. But they are an important part of a much bigger picture. There are so many items, especially in the UK that we use only once before throwing away. Over time, things like bottles, carrier bags and toys all break down into smaller pieces. So most microplastics in the oceans are from much larger items."

In Autumn 2017, the UK government announced plans to call for evidence on how taxes or other

charges on single-use plastics such as takeaway cartons and packaging could reduce the impact of discarded waste on marine and bird life. At NERC we are working with businesses to see how research could look at ways to reduce the amount of plastic that goes into the environment.

Lots of NERC-funded science was used in a House of Commons Environmental Audit Committee report which led to the microbead ban.

<http://bit.ly/EACplastics>



Written by **Julia Horton**

# How cities draw the heat

**Better predictions of heatwaves save lives.**

It is 15 years since the UK sweltered in the record-breaking 2003 summer heatwave.

While the sunshine was welcome to many, it also brought deadly consequences, with more than 2,000 people across England and Wales dying in the stifling heat. Some 800 of those deaths were due to air pollution.

The death toll spurred the government to improve a nationwide heatwave warning system using scientific research from NERC. The new system provided more accurate predictions of growing smog as temperatures soared.

## **Toxic ozone**

As the mercury rises, so too do levels of toxic ground level ozone. The ozone layer high up in the atmosphere shields people from the sun's harmful ultraviolet rays and the threat of skin cancer. Whereas ground level ozone is the main component of smog, which triggers conditions like asthma and bronchitis.

## **Taking the heat off health services**

Professor Alastair Lewis did pioneering work funded by NERC to predict peaks in smog during heatwaves. He found that trees in the UK also cause natural pollution, by emitting a chemical called isoprene that reacts with manmade pollutants to increase smog further. As a result, natural emissions were included in future air quality forecasts, making them more accurate. These air quality forecasts are part of a heatwave warning system that the Met Office has estimated saves 24 lives for every ten days of heatwave alerts.

## **Home fires worse than idling lorries**

But air pollution comes in many forms caused by multiple sources.

There is growing concern now in winter about a key source far closer to home for many people, who could make their own lifesaving decisions to reduce pollution.



Sometimes environmental scientists appear to be here just to deliver bad news, but we also have positive stories to tell. This is crucial evidence which can help the government develop plans for meeting targets to reduce roadside pollution.

Alastair, now deputy director of NERC's National Centre for Atmospheric Science (NCAS), explains: "Between 10,000 and 40,000 people die in the UK each year because of air pollution so even a modest reduction in emissions can make a substantial difference.

"Our air quality is very much better than it was 30 years ago, when the focus was on major industrial sources like power stations. There are still big improvements we can make to reduce the number of deaths and the costs to peoples lives and the environment. Lots of that now lies with what individuals choose to do.

"The next challenge for the UK will be particulate matter, or particulate matter, a serious pollutant from a huge number of sources. I think people would be surprised by the contribution of things like coal fires and woodstoves in their homes."

Ministers have warned that these popular stoves and other domestic heating appliances were the single largest contributors of particulate matter in the UK in 2015, producing around 40% of total particulate matter emissions.

Ministers are urging people to switch to cleaner fuels and more efficient appliances. They also recently (end January 2018) appealed to people to submit their views on how to reduce soot and smoke from their homes ahead of a new clean air strategy consultation, expected later this year.

### Ahead of schedule on traffic fumes

NERC-funded research is also playing a key role in addressing traffic fumes, to ensure efforts to cut pollution are based on the best understanding of the causes – giving politicians the greatest chance of success.

Last year ministers announced a ban on all new conventional petrol and diesel cars by 2040 as part of a £3.5 billion plan to tackle nitrogen dioxide emissions from traffic.

The aim is to help the UK meet key national and European limits on air pollution from roadside traffic fumes. Many UK cities frequently breach these limits, producing illegal levels of pollution linked to serious health problems for thousands of people nationwide. Young children often get the worst of the fumes because they are closer to exhausts.

However, a recent study by NCAS and the University of York, which Alastair co-authored, revealed that the UK is likely to meet its targets several years sooner than the government's current forecast.

The reason for that, perhaps surprisingly, is the finding that as diesel cars age, they emit less nitrogen dioxide pollution.

They made the unexpected discovery through a detailed analysis of vast amounts of existing data collected by the UK as part of Europe-wide information records held by the European Environment Agency. The government's own predictions were based on emissions forecasts instead of the actual figures recording the surprise reduction.

Alastair says: "Sometimes environmental scientists appear to be here just to deliver bad news, but we also have positive stories to tell. This is crucial evidence which can help the government develop plans for meeting targets to reduce roadside pollution."

Alastair and his team will now look at the same official data in a bid to find out more about particulate matter pollution.

## In numbers

**2,139**

deaths in the UK blamed on the 2003 summer heatwave.

**2040**

date by which sale of new conventional petrol and diesel cars will be banned in the UK.

**Up to 100,000**

different organic chemicals that can make up a single air pollution particle.

**10,000-40,000**

estimated early deaths per year in the UK each year due to air pollution.

**£15 billion**

how much air pollution costs the UK economy each year in treating related health conditions and other issues.



A wood-burning stove can emit more particulate matter than an idling diesel lorry.

# Helping species on the move

Written by Julia Horton

“Could this be the answer to conserving life, the universe and everything?”

Phillip Whelpdale, of the Yorkshire Wildlife Trust, admits to being ‘tongue in cheek’ with his bold, questioning reference to cult science fiction comedy, *The Hitchhiker’s Guide to the Galaxy*, in which a supercomputer mysteriously calculates the meaning of life as 42.

But working out where species will thrive in future as global warming pushes them north seeking cooler places, and key habitat is lost as industries and housing spread, is a serious problem.

Dr Jenny Hodgson at the University of Liverpool developed a way of showing how quickly species shift their range when their habitat gets broken up. She used that to develop a pioneering computer programme called Condatis, funded by NERC, to give animals the best chance of survival in an ever-changing environment.

The programme pulls in data from conservationists’ understanding of where wildlife is now and where animals might move in future. From there it creates maps predicting how quickly creatures will be able to shift from one site to another and which routes they are most likely to use.

After a few weeks trialling the system to look at restoring grassland for species including butterflies, Phillip

thinks it has real potential to help charities UK-wide decide where to create, improve and connect vital meadows, woods and other habitat.

He said: “Historically, nature conservation was about having a nature reserve with a fence around it and telling everyone to keep out. Now it’s about having more, bigger and better joined up sites. Wildlife trusts around the country have identified networks of these living landscapes.

“It’s early days with the software for me but I can see that the cluster sites we have here for restoring grasslands, which have become fragmented as farming has taken over more of the land, seem to coincide with the bottlenecks shown by Condatis for species moving from site to site [where more habitat is likely to be needed as a result]. That suggests we have been choosing the right locations for creating a better living network of habitat.





Dr Kath Allen,  
conservation biologist,  
University of Liverpool.

Condatis uses data about UK wildlife habitats that's been generated over decades by NERC-funded research.

“We do need better data (because the system is only as good as the information conservationists type into it) but I think the software could help different groups and areas across the UK work together more effectively in future.”

Phillip is among several conservationists who were invited to the University of Liverpool in January 2018, where Condatis was created by conservation biologist Dr Jenny Hodgson, to help experts there make further improvements to the programme.

One of the key advantages for charities the software offers is a chance to compare different potential locations for restoring habitat before investing in them – crucial information for organisations with limited resources.

### Making a B-line for the best habitat

Another charity, Buglife, has been successfully using the software for several years to restore links between wildflower meadows across the UK for insects under a scheme known as B-Lines.

Jamie Robins, charity projects manager, says simply: “If we have ten sites where we could improve habitat and we can't restore all of them the programme shows us which to target to get most value for money.”

There are lots of factors which affect conservation, including the likelihood that landowners will be willing to work with charities.

Dr Kath Allen, a conservation biologist at the University of Liverpool whose job involves helping environmental groups get the most from Condatis, says a newer version due out later this year will address that and other issues too.

She says: “The current software doesn't tell you how easy it might be to restore a certain habitat. If the land is owned by another conservation charity, like the National Trust, restoration will probably be easier than if the land is owned by industry. The new version will take that into account too,

**If we have ten sites where we could improve habitat and we can't restore all of them the programme shows us which to target to get most value for money.**

creating a kind of heat map highlighting sites that will deliver high benefit in relation to their cost (such as the time and effort to persuade landowners).”

The new software will also mean that charities will no longer have to download and run Condatis, which can take days and requires up-to-date technology that NGOs often cannot afford.

Condatis is also set to be used further afield including South East Asia. Conservationists in Borneo hope it will help to identify and connect the most likely areas for wildlife to survive as rainforest is destroyed by both legal and illegal logging.

Longer term, the Condatis website will let charities around the world share invaluable information on how they are using the software – perhaps finally providing the answer to conserving life on earth, if not quite the universe and everything else.

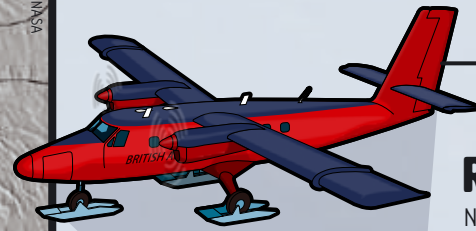
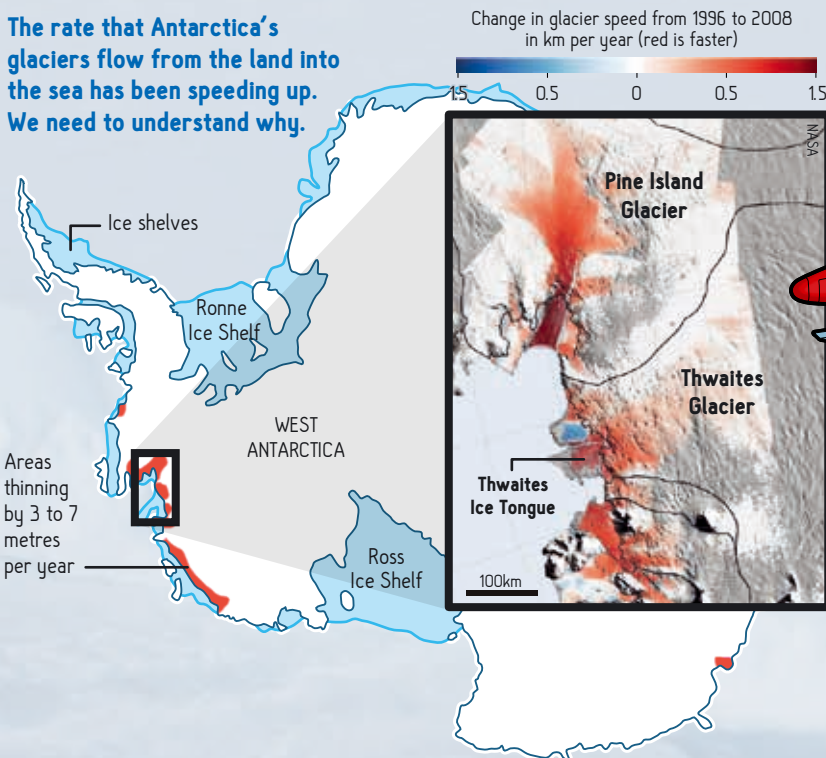


Find out more on the Condatis website: [wordpress.condatis.org.uk](http://wordpress.condatis.org.uk)



# INVESTIGATING THWAITES GLACIER

The rate that Antarctica's glaciers flow from the land into the sea has been speeding up. We need to understand why.



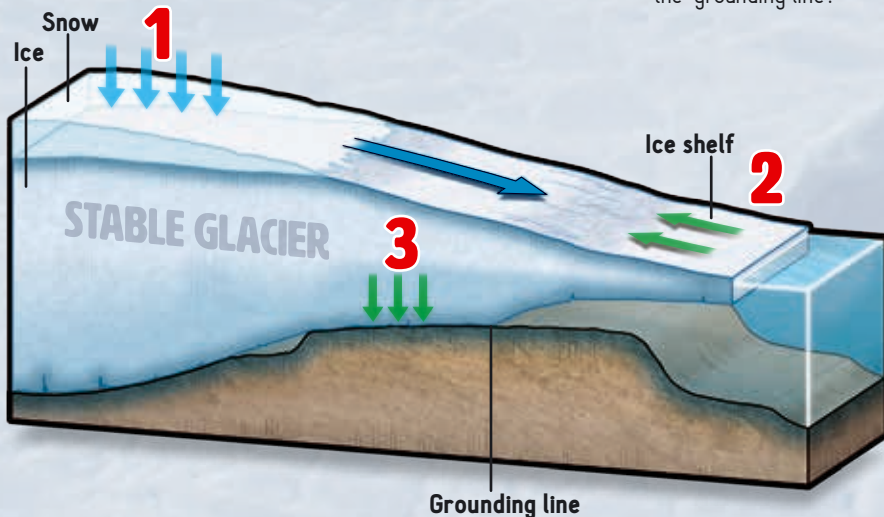
## RADAR

NERC's Twin Otter aircraft will take radar measurements to look deep below the surface of the ice and build a clear picture of how different layers of ice and the bedrock interact. This is crucial in understanding how climate change will affect large ice sheets.



## FROM STABLE GLACIER...

- 1 A stable glacier is in rough equilibrium. Annually, the snow falling on the glacier replaces the ice flowing into the ocean.
- 2 The floating part of a glacier, the ice shelf, acts like a cork or dam, holding back the ice upstream.
- 3 Sediments and water beneath the ice affect its speed — as does how much of the glacier is in contact with the land at the 'grounding line'.



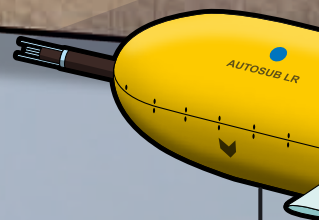
Glacier thins



## ...TO RETREATING GLACIER

- 4 The equilibrium of the stable glacier is lost. There is no longer enough snowfall to replace the increasing ice flow into the ocean. All the lost ice ends up in the ocean, raising global sea level.
- 5 Warm currents under the ice increase, melting the floating ice shelf and causing more icebergs.
- 6 The thinning reduces its effectiveness in damming ice flow
- 7 As more of the glacier begins to float the glacier flows faster.

At 182,000 square km, Thwaites Glacier is one of the largest glaciers on the planet. It covers an area the size of Great Britain or the State of Florida. It is so remote that only a very few human beings have ever set foot on it.



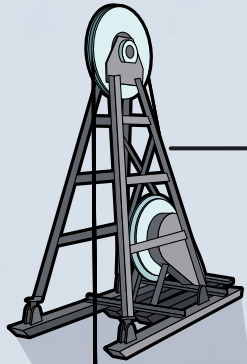
## SUBS

Autonomous underwater vehicles travel deep beneath the ice shelf to investigate cavities under the ice shelf and how a warmer ocean affects them.



Thwaites Glacier and Pine Island Glacier are two of the biggest and fastest-retreating in Antarctica. If both collapsed, global sea levels could rise by over a metre. Without them, the entire West Antarctic Ice Sheet could be more likely to collapse, leading global sea levels to rise by over three metres.

A five-year collaboration is investigating what's causing ice loss at Thwaites Glacier and how it will impact global sea levels. This is a joint venture between the U.S. National Science Foundation and the UK's Natural Environment Research Council. The eight projects use a suite of technologies.



### HOT WATER DRILLS

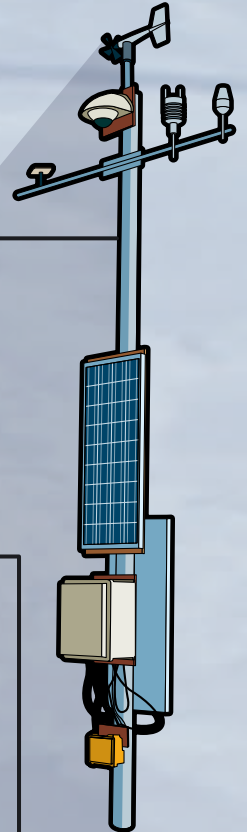
These sample the seabed beneath floating ice shelves and sediments beneath grounded ice. They also take ice cores from the ice shelf, which will show us what the climate was like in the past.

### SEISMOMETERS

An array of seismometers will measure conditions under the ice and detect changes in movement, in the same way we monitor earthquakes.

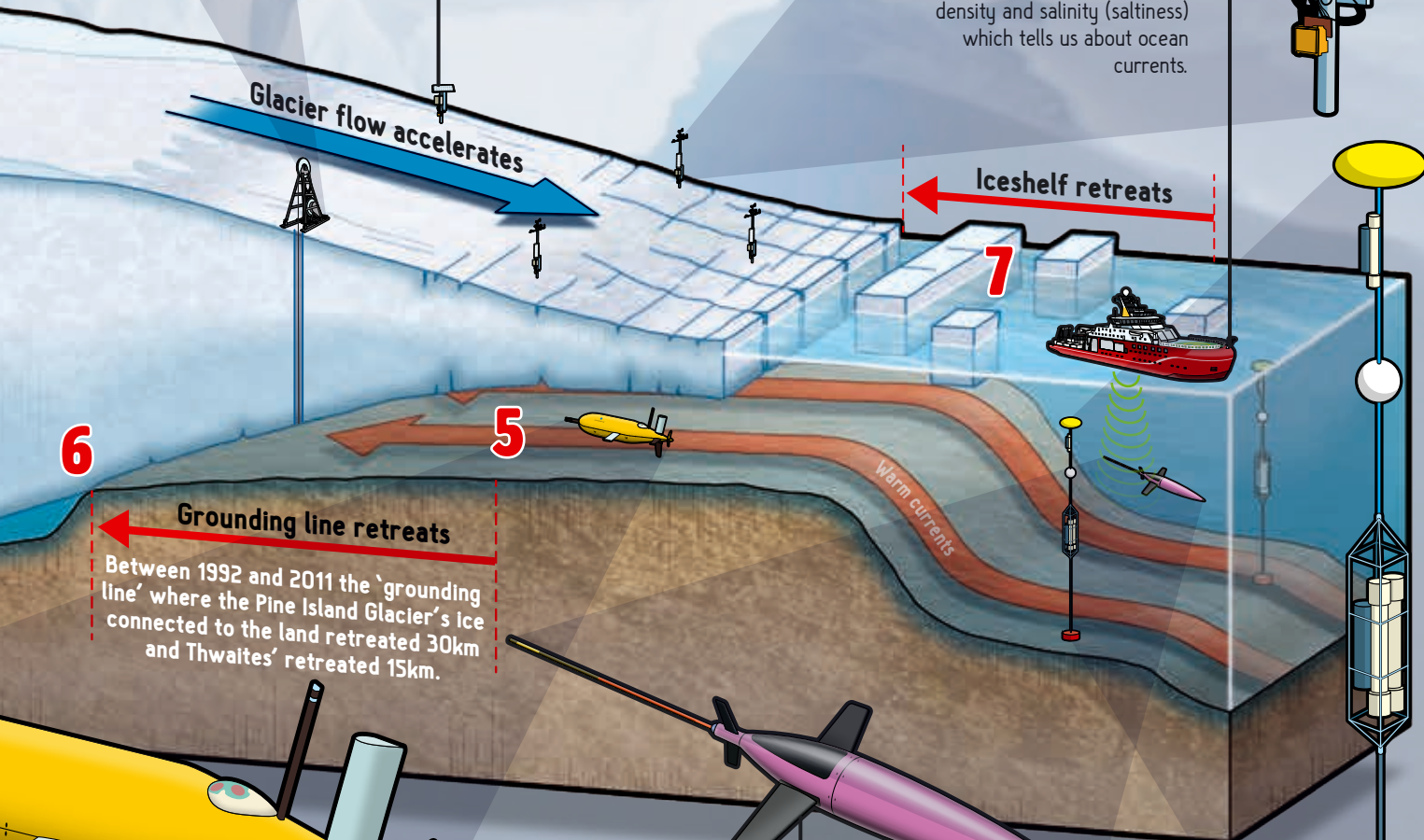
### REMOTE STATIONS

Multi-sensor remote autonomous stations will measure weather, ice conditions, ocean currents and temperature from on top of the ice shelf or on sea ice.



### SHIPS

Ships will use sonar to map the seafloor. They will also measure the water's temperature, pressure, density and salinity (saltiness) which tells us about ocean currents.



6

5

7

### OCEAN GLIDERS

Gliders are underwater robots that use changes in buoyancy to move through the water instead of motors. These will investigate ocean currents by measuring temperature, pressure, density and salinity.

### OCEAN MOORINGS

A suite of sensors anchored to the sea floor and supported by floats monitoring water temperature, salinity and density – as well as changes in conditions beneath the glacier.



# Building a wind farm out at sea

The planned Dogger Bank wind farm would generate cleaner power for up to four million homes.

© Statoil: Sheringham Shoal off the coast of Norfolk.

As a geologist you never know what nature is going to throw at you.

At the moment I am involved in ongoing work to help find the best site for offshore wind energy developments. We're mapping the seabed and beneath off the northeast coast of the UK.

The UK has an enormous capacity for renewable energy and the planned wind farm at Dogger Bank will be the biggest in the UK so far, generating cleaner power for up to four million homes.

The seabed is still a bit of a mystery though, which is why it's so important to find out as much as possible about what it looks like and what it's made of.

The best weather for our data gathering trips out to the North Sea usually come between April and September. But even then we still have 'interesting' days when it's too rough to think much beyond staying in your bunk and not falling out.

The renewable developers are looking for dense marine sand, which is ideal for foundations for turbines and for burying cables, and that's what they thought they had at Dogger Bank. But our research

has shown that that's not what's there. I had to break the news that the ground beneath the seabed there looks like someone has rucked it all up much like a rumbled bedsheet!

The old geological maps suggested that Dogger Bank was clay. I think many scientists had thought it was like a layer cake, with marine sands and then glacial sediment from the Ice Age, followed by more marine sands after the ground was flooded again.

That is all there but it's more complicated than that. As we analysed the new data, we looked for features in the buried landscapes that could be causing this complexity. We wanted to know why we weren't finding that neat layer cake we'd expected.

What is there is a buried glacial landscape and there are huge, long, curved ridges up to 50 metres high in big arcs spanning up to 200km. They were formed when the area was above sea level and covered with ice in the last Ice Age. Back then, Dogger Bank was part of a large land mass connecting what's now mainland Europe to Britain. We know that Dogger Bank was once above water because some



## NERC science enables growth of UK renewables

NERC data and expertise are used by regulators, energy companies and investors to reduce the risks and costs of renewable energy developments.

Our science has been key to assessing the safety of wave energy turbines to seals and other marine mammals, the effects of wind turbine installations on coastal erosion, and the feasibility of tidal barrages.

Since 2010, NERC's British Geological Survey and National Oceanography Centre have co-led high-quality mapping of the UK seafloor for use by industry, marine planners and conservation groups.

By combining information collected by a large number of organisations undertaking marine surveys, the MAREMAP programme provides detailed and up-to-date maps that are available for all users of marine geoscience information.

The partnership informs responsible decision-making about marine activities and delivers better value for money to support UK industries and help Government to meet its environmental and development objectives. If organisations were to do this themselves, it would cost £700,000 per 1,000km<sup>2</sup>.

Find out more at [www.maremap.ac.uk](http://www.maremap.ac.uk)



We've provided vital information for offshore wind farm developers.

Written by **Dr Carol Cotterill**, Marine and Coastal Geoscientist at the British Geological Survey

of the core samples we collected there contained evidence of various flowers and pollens.

It's made of similar clays which have all been mashed together by ice sheets, creating a deformed landscape that looks as though it's been bulldozed. And all of them behaved differently when we tested them.

You don't see features like this on such a big scale anywhere else around the UK. In other places these glacial landscapes have been eroded by the sea when it came back and flooded the land. In some places it's been disturbed by buildings and roads.

For offshore wind farm developers we've provided vital information because they can engineer 'for anything' once they know what's down there. We will continue advising them on proposed sites for every turbine, modifying the geological model as we get more information.

For scientists, it's a fascinating insight into the past Ice Age and how it has affected the geology of the seabed today.

# Securing the UK's natural carbon storage

Written by **Julia Horton**



Beyond beautiful: the UK landscapes holding onto carbon.

The UK's spectacular scenery attracts millions of visitors from around the world.

Iconic heath, peatland and sea lochs don't just look beautiful though. They are shaped by the changing climate. As they change they create a picture of the impact of global warming that can help scientists find solutions.

The landscape also plays a key role in climate change by storing carbon so it is not released into the atmosphere.

But just how the processes link together, and how plants and soils respond to global warming, remains unclear. NERC is funding research to find out how land and sea could be managed to safeguard its carbon stores as well as the people and wildlife relying on it for survival.

In Wales, experts at NERC's Centre for Ecology & Hydrology (CEH) have spent nearly 20 years improving our understanding of the impact of reduced rain and raised temperatures on upland heath and peatland traditionally used for hill farming.

## Curtains for carbon

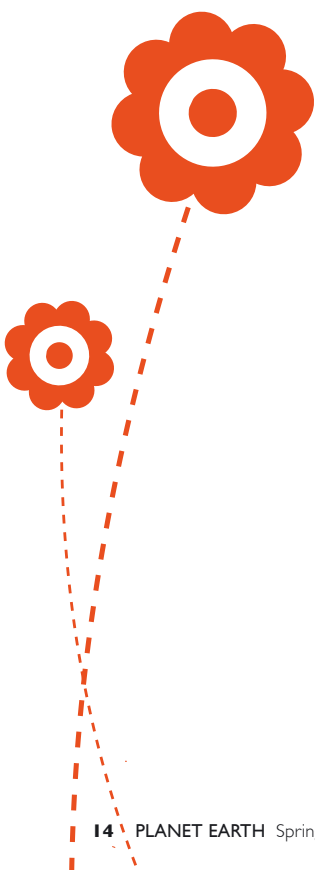
The work involves using rain and light sensors to activate plastic 'curtains' on a set of experimental plots of land on the hillside to manipulate soil moisture and heat.

They've found that in plots where they created conditions mimicking drought, the soil lost up to 10% more carbon.

The results suggest that climate change can be a vicious circle. As global warming causes more extreme dry spells, the soil's ability to store carbon gets reduced. That in turn can lead to even more carbon being released into the atmosphere and so more warming.

Activity from bacteria, fungi and plant roots within soil cause carbon to be stored or released.

Sabine Reinsch, CEH soil ecologist, explains: "When soils are water-logged, organisms such as microbes and fungi, and also plant roots, are less active so they release less carbon in the form of carbon dioxide and other greenhouse gases. When soil





## Sediments in sea lochs also hold the same amount of carbon as two million mature coniferous trees.

dries out, and stays dry, these processes speed up and they release more carbon.”

“Our experimentally dried plots are now permanently dry, losing carbon all year round.”

Another key finding from the ongoing work was that soils warmed at night lost less carbon than expected. The team put that down to a surprising amount of moss which grew on the soil surface. It seems to have prevented soil from drying out, which then reduced carbon emissions.

Sabine adds: “That was not what we were expecting because warming also causes soil to dry out. We don’t really know what the moss is doing to the soil’s properties so we’re hoping a PhD student can look into that further.”

CEH is currently gathering and analysing daily real-time data on soil moisture and temperature to help reveal more about how that influences the amount of carbon it stores and releases.

In the meantime Sabine said: “The important point is that whatever land management does to peatland soils to keep the soil carbon locked away, we need to manage the soil water cleverly.”

### What makes peatland tick

In Scotland, NERC is also funding work to find out how peat bogs store carbon to improve multimillionpound restoration work by governments.

Peatland here currently holds more than 1.6 billion tonnes of carbon but it is being lost due to damage caused mainly by the forestry sector.

Nicholle Bell, NERC soil security programme research fellow at the University of Edinburgh, is looking for protective molecules in the peat which experts suspect may be the key to how it stores carbon.

She says: “If we can understand what makes peatlands tick we can help to keep them carrying out vital ecological services, including carbon capture.”

### Sea lochs

Last but not least is the seabed, where NERC-supported research has found plays a significant role in storing carbon long-term.

New ways of analysing the content of sediments up to 70 metres deep in Scottish sea lochs have allowed experts to make the first scientific estimates of the amount of carbon held in the mud.

That amount, some 640 million tonnes, is roughly three times less than that stored in Scotland’s peatlands. But as the fjords cover a far smaller area than peatland – at just 1,221km<sup>2</sup> compared to 17,270km<sup>2</sup> – they are a far more efficient carbon store.

Sediments in sea lochs also hold the same amount of carbon as two million mature coniferous trees.

Lead researcher, University of St Andrews post-graduate Craig Smeaton, says: “Though these important coastal and marine carbon stores are no longer forgotten this is just the first step to truly understanding carbon in the coastal ocean and how it fits into the global carbon cycle.”



Erik Paterson/Flickr



### UK Peatland Code



NERC scientists informed the development of the International Union for Conservation of Nature’s Peatland Code, the UK’s first regulated scheme for businesses to support peatland restoration work using carbon finance.

Find out more at [www.iucn-uk-peatlandprogramme.org](http://www.iucn-uk-peatlandprogramme.org)



# Skin of the Earth

Written by **Julia Horton**



Professor Tim Daniell.

It might be easy to dismiss the earth beneath our feet as just so much dirt.

But without it humankind would not exist.

As former US president Franklin D. Roosevelt once said: “The nation that destroys its soil destroys itself.”

He was speaking in the 1930s after years of severe drought and relentless winds turned states across America into the ‘Dust Bowl’. The notorious disaster wiped out crops and livestock and forced countless families across America to abandon their farms.

## More food, less land

Nearly a century on and the climate remains a huge threat to agriculture and survival around the world.

## Keeping up with demand

It is predicted that 60% more food will be needed worldwide by 2050 to feed the expanding global population. The government has announced £90 million of new funding to help businesses, researchers and industry to transform food production.

Find out more at <http://bit.ly/transformingFP>

But now exploding populations are challenging the world to keep more people fed using less – and less good quality – land.

The problem is perhaps most stark in China, where millions of people have been leaving the countryside to move into rapidly growing cities spreading onto former farmland. The vast influx is creating serious environmental challenges from soil erosion to increased use of contaminated land as food production expands in growing urban areas.

## A planetary ‘skin’

NERC experts stress that it is not just soil that matters, it’s what they call the Earth’s Critical Zone. This is the vital area from the bedrock up to the tree tops. Likened to a ‘planetary skin’ on which human life depends, it contains, along with soil, vital rocks, air, water and organisms.

In the right balance they collectively sustain life by providing clean air and water, food and renewable energy.

NERC scientists and colleagues at the National Natural Science Foundation of China are working together on a joint £10million project entitled the Critical Zone Observatory Programme. It was set up to find out how to produce enough food to meet demand in a sustainable way.



### Too much of a good thing

One of the problems has been high use of chemical fertiliser. Professor Tim Daniell, chair in soil microbiology at the University of Sheffield and research leader in soil ecology at Scotland's James Hutton Institute, is working on a solution using animal manure in Ningbo, one of the fastest growing cities in the Yangtze delta.

Tim says: "We use fertilisers to replace nutrients in the soil as they are used by plants for growth, but in China they often apply too much fertiliser because it has been subsidised by the government there and there have been some issues (with farmers not being fully aware of the possible risks).

"Too much fertiliser can increase nitrogen in the soil to toxic levels. Producing fertiliser in factories requires a lot of energy and also creates greenhouse gases. If too much fertiliser is used, it can leach into rivers where it pollutes the water, or create more greenhouse gas emissions."

### Is pig poo the answer?

The project Tim is working on involves trialling organic fertiliser from pig slurry as a more sustainable alternative to chemical fertilisers for growing wheat, rice and vegetables.

Ploughing back animal waste into fields creates a cycle of food production from plant to animal and back again, which is more efficient. But it is not without it's problems either, it could transfer potentially harmful bacteria from animals to humans and there are other things to consider too. Tim said: "While it might be sensible to use an organic fertiliser like pig slurry because you're not wasting that resource, the risks might include adding contaminants which you don't want in a crop, such as heavy metals like zinc or pharmaceuticals (from drug treatments given to livestock). These might become harmful to people eating food produced from treated crops. They could also drive antibiotic resistance. The question is, if you did that for 100 years would you be creating a problem? We're trying to find a balance between opportunity and risk."

It is too early for any results yet since the work began about a year ago, but the need for answers is clear. Tim concludes: "I think working out how to provide food sustainably as populations rise is the major challenge facing our society today."

Digging up the facts on

# SOIL



## 500

Years to produce an inch of topsoil, the most productive layer of earth



A handful of soil contains more micro-organisms than people on the planet



Soil provides all the nutrients plants need to grow



Fertiliser is added to replace those nutrients as plants use them up



Roughly 10% of the world's carbon dioxide emissions are stored in the soil





# Mining for answers in the ocean's archives

Written by **Aliya Mughal**

With a death toll of more than 250,000 people, the Boxing Day tsunami of 2004 was one of the most devastating disasters of recent history. It was triggered by an earthquake that struck off the coast of Sumatra in Indonesia. In 2016, Professor Lisa McNeill led a scientific expedition to investigate where it all began - in the seabed.

"Sampling an earthquake zone in situ is one of the holy grails of modern earthquake studies," said Lisa. "Although we now have very sophisticated techniques to remotely record the earthquake process, we really needed to sample the rocks

where the real action goes on."

The expedition was conducted by the International Ocean Discovery Program (IODP), which for the past 50 years, has been sending scientists, researchers, engineers and technicians across the world to delve into the Earth's archives.

## Secrets of the deep

By drilling deep beneath the ocean, IODP expeditions extract samples of ancient sediments and rocks, which contain a detailed record of how the planet has evolved over millions of years.

In the case of the Boxing Day tsunami, those sediments had become compacted over the course of nine million years. As temperatures rose, they got stronger and denser, eventually leading to the shift in tectonic plates that triggered the earthquake.

In 2011, the world was stunned by another tsunami, this time in the Tohoku region of Japan, which claimed 20,000 lives, destroyed 230,000 homes and generated the Fukushima nuclear meltdown.

Just over a year later, scientists sailed out to the Pacific Coast to investigate. Before this expedition, people used to think that earthquakes got weaker as they travelled up through the Earth. But this research trip found out that the Tohoku earthquake actually got stronger and stronger as it neared the ocean floor.

These findings could help scientists predict the likelihood of future natural hazards in regions with similar geological conditions. Policymakers could use the evidence to create greater safeguards for coastal communities.

Professor Lisa McNeill helps carry a core from the sea bed.

Tim Fulton, IODP JRSO



## Informing UK and international climate policy

NERC scientists and their research have been central to all published IPCC Assessment Reports, at all levels from expert reviewers to lead author. They provided the foundation for the Paris agreement where 195 countries agreed to try to limit global warming to less than 2°C above preindustrial levels.



## Changes in the water

As well as earthquakes, scientific data like this captured by the IODP is one of the most powerful indicators of climate change. It shows a warming climate, rising sea levels, melting ice sheets and natural hazards. The International Panel on Climate Change (IPCC) relies on data like this to influence environmental policies that determine how the world responds to climate change.

In its 2013 report, the IPCC referenced investigations led by Professor Stephen Barker, who uses IODP deep core sediments to understand climate change in the past. His team found that during the last ice age (110,000 to 12,000 years ago), in the Northern Hemisphere, temperatures rose intermittently by more than ten degrees Celsius within a few decades. While over the same period, temperatures in the Southern Hemisphere changed more gradually.

Warmer water temperatures cause sea ice to melt, which adds freshwater to the ocean, raising the sea level. The oceanic changes documented by scientists provided the IPCC with the first concrete evidence of how climate change impacts the way water circulates around the ocean. Ocean circulation is important because it has a huge effect on weather and climate conditions in different regions, as the movement of water distributes the heat that the ocean absorbs.

## The International Ocean Discovery Program

The IODP has been exploring under the ocean floor since 1966. Scientists from different disciplines, and from more than 25 different countries, are part of a mission to document and analyse Earth's history and dynamics through time. The data they collect is publicly available, so anyone can explore the world beyond our shores. NERC pays a £2.6 million annual subscription to IODP to enable the UK scientific community to go on IODP-funded drilling expeditions.

## The tide is rising

The state of the world's oceans tells us a lot about climate change. Oceans have absorbed a lot of the excess heat caused by global warming and that causes the water to expand – pushing up sea levels.

Ocean levels could rise by a few feet by 2100, which for the 150 million people living within three feet of current ocean levels, would have serious consequences.

## A heated debate

Professor Carrie Lear is working to understand how levels of ice around the globe have changed over time.

“The long sediment cores drilled by the IODP provide records of climate change and ice volume change over millions of years,” said Carrie.

Records like this recently made the scientific community realise that the Antarctic ice sheet is much more susceptible to change than previously thought.

Findings like this are important for policymakers. “Sea level change due to global warming this century could be larger and more rapid than previously thought,” added Carrie. “This means that we need more stringent policies to be made now if we are to minimise the effect on sea level rise by the end of the century.”



JANSTEC/IODP



Tim Furlong, IODP/RSO

Ships use on-board technology to take samples from deep in the sea bed.



# How much

Written by Dr Phil Goodwin, University of Southampton and Professor Ric Williams, University of Liverpool

We know that global warming is taking place and its main cause is increasing levels of carbon dioxide in the atmosphere.

The Paris climate agreement provides a rallying call to nations to limit carbon emissions and to keep global temperature rise well below 2°C above the pre-industrial period. This would significantly reduce the risks and impact of climate change.

What is important for policy makers is – how much time is left before we reach the Paris warming targets?

If there is only a few years, we'll need to focus on mitigating the adverse effects of a warming climate. Whereas if we have many decades then there is more opportunity to develop and implement new technologies and policies for a more carbon-efficient future.

## A new approach

We are not the first team to make a prediction about this, but we can be confident in our findings because of the new approach we applied.

Many previous simulations of global warming do not work well if you try to get them to simulate what has happened in the past. We think that is an important test for a simulation – if it can't replicate the past, it probably is less reliable for projecting the future.

To get our results, we ran 100 million simulations of carbon emissions and warming. Then we took only the results that recreated past climate accurately, which left us with about 30,000 projections for the next century.

## TIME IS LIMITED

We have found that, if nothing is done to curb increasing carbon emissions, we will reach 2°C warming in 30 years and 1.5°C of warming in under 20 years.

## When do we reach 2°C? It all comes down to emissions

To keep below 2°C of warming, we found that the total amount of carbon emitted from the start of 2018 needs to remain less than



time is left to meet the

# Paris climate agreement?

1,300 to 1,830 gigatonnes of carbon dioxide. The sooner we emit that much carbon, the sooner we reach 2°C.

Without action to curb emissions, 2°C warming will be reached between 2038 and 2050.

## A range

All our results are in ranges because there are some factors we can't be certain about. For example, we are uncertain as to the exact effect of clouds on warming, or the effects of dust in the atmosphere in reflecting sunlight, but we have a fairly good idea of the upper and lower limits of these effects, so we run lots of versions of the simulation within those limits. That gives us lots of slightly different results and you can see the median result shown on this graph in the dark blue line. The wider, light blue shading shows the upper and lower uncertainty ranges of our distribution of projections.

## Time to act

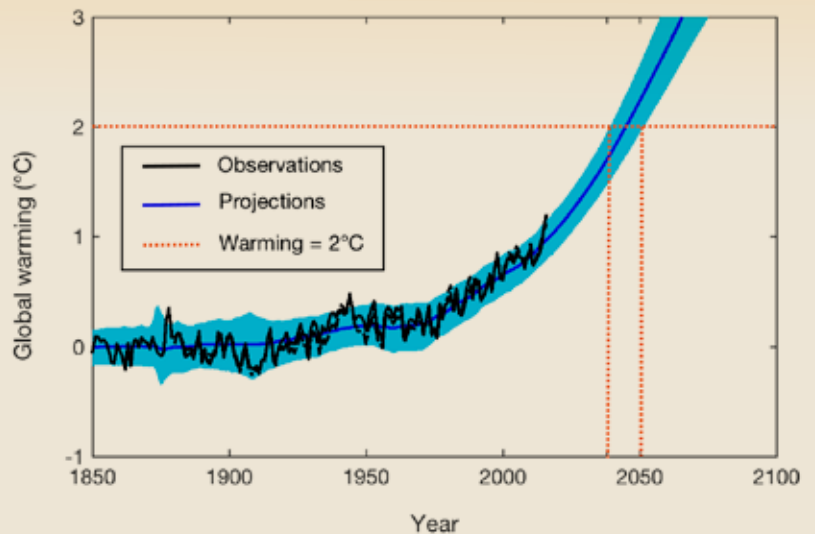
To develop a more carbon-efficient and ultimately carbon-neutral future, we need to develop and adopt new technologies, and plan and organise our societies to use energy more efficiently and reduce carbon emissions. We also need to explore ways of capturing carbon to reduce how much carbon dioxide is in the atmosphere.

Achieving this goal is very challenging within 10 to 20 years, so we are unlikely to stay below 1.5°C, but we might be able to manage it within 30 to 40 years and stay under 2°C.

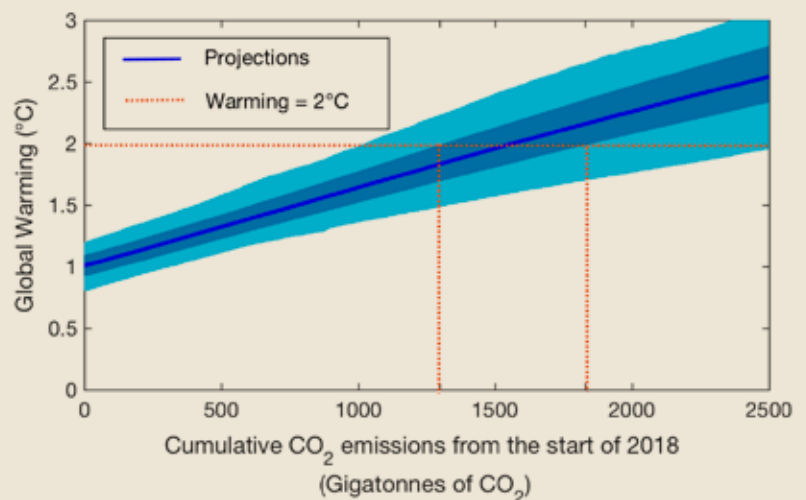
We all face challenges in making this transition, but the earlier that we start moving towards a more carbon-efficient future the easier it will be to meet these warming targets.

If we don't make a concerted effort now, within a couple of decades we'll be trying to decide how to cope in a warmer world and trying to find out how much warmer the world might become.

## WARMING PROJECTIONS



This graph shows when we are likely to reach 2°C warming if there is no change in emissions.



This graph shows when we are likely to reach 2°C warming in relation to carbon emissions.

Find out more about this work in their recent article in *Nature Geoscience*: doi: 10.1038/s41561-017-0054-8.

[www.nature.com/articles/s41561-017-0054-8](http://www.nature.com/articles/s41561-017-0054-8)

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