NERC SCIENCE OF THE ENVIRONMENT

Spring/Summer 2018

# Planet Earth

NERC is part of UK Research and Innovation – nerc.ukri.org

## Hay Festival Trans.MISSION

When top artists and environmental scientists meet

Aardman, Daniel Binns

# NERC at Hay Festival

## About us

## Natural Environment Research Council

Hello Hay Festival goer! Welcome to *Planet Earth* magazine, bringing you the latest news about environmental research funded by NERC. We are part of UK Research and Innovation and our leading research, skills and infrastructure help solve major environmental issues.

NERC science explores the processes that our planet, our lives and our economy depend on. The scientists we fund explore every corner of the Earth, its fields and valleys, its deserts and poles, its oceans and beyond.

Find out more at **www.nerc.ukri.org**

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# The environment is everyone's business

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 we have three NERC-funded scientists working with artists at Hay Festival and our family show *Operation Earth* running at science centres around the UK.

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 the Natural Environment Research Council, part of UK Research and Innovation.*

## 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, UK Research and Innovation brings together the seven Research Councils, Innovate UK and 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**

**Want to hear more about environmental research? Sign-up to our emails:**
reg.nerc.ac.uk/planetearth-email

# Hay Festival Trans.MISSION

For the last 31 years, Hay Festival has sought to bring the best thinkers from the worlds of science and the arts to share their ideas with global audiences. Featuring over 600 of the world's greatest writers, global policy-makers, pioneers and innovators in 800 events across 11 days, the festival showcases the latest ideas in the arts, sciences and current affairs, alongside a rich line-up of music, comedy and entertainment for all ages. A galaxy of literary stars gather to launch new work, while the biggest ever HayDays programme give young readers the opportunity to meet their heroes and get creative.

Hay Festival's Hay on Earth programme has run for the last 12 years and looks to address the big issues facing the planet, whether it's through raising awareness with debates or looking after our own direct impacts. These include 100% renewable mains power for the festival, looking to improve on last year's recycling of 80% of total waste produced on site, banning of plastic straws, stirrers and being the first festival in the UK to trial a new reusable hot drink cups system.


Hay Festival is one of the few places where artists, scientists and policy-makers share the same stage, blending disciplines and art forms in exciting ways.

The partnership with NERC allows us to take this one step further by bringing the two worlds together before the festival, to see what can be created from a longer-term collaboration. With NERC's access to cutting-edge scientists and Hay Festival's contacts in the arts world, there was a perfect opportunity to create something new and exciting. The result was Trans.MISSION, pairing leading scientists with award-winning artists to communicate innovative science to new audiences at Hay Festival 2018 and beyond.

The new partnership with NERC is taking us in an exciting direction and we can't wait to see what these collaborations spark.

**Andy Fryers**
*Hay Festival Sustainability Director*


**Above: Still from Aardman Director Dan Binns' short film about air pollution and how our homes help exacerbate the problem. Dan worked with atmospheric scientist Professor Ally Lewis on this project. Meet the artists on page 2.**

*Come to*
## Operation Earth

Operation Earth is now on at science centres across the UK. This show and activities give families with children aged 6 to 11 the chance to find out more about environmental science.

It's a great way to learn about challenges facing our planet and tackle them too.

Find an Operation Earth show near to you at **www.operationearth.co.uk**

# *Five minutes with the* Trans.MISSION *artists and scientists*

Hay Festival and NERC have joined forces for the first time to launch Trans.MISSION, a project pairing leading scientists with award-winning artists to communicate cutting-edge science to new audiences at Hay Festival 2018 and beyond.

What happens when you bring together two people at the top of their game but from different spheres? We found out in these quickfire Q&As with each pair.

See all the artwork at nerc.ukri.org/PlanetEarth

Watch all the talks at: www.hayfestival.org/hayplayer

Chris Haughton

# Chris Haughton and Dr Emily Shuckburgh

Deputy head of the Polar Oceans Team at the British Antarctic Survey, Emily, a leading climate scientist, mathematician and author has been working with an award-winning designer, author and illustrator Chris Haughton (*A Bit Lost, Oh No George!* and *Shh! We Have a Plan*) to explore polar science and climate change.

**What made you interested in doing this project?**

**Chris:** I am very excited to try to visualise this research with illustration. I'm an illustrator and so I prefer to tell stories as much as possible through pictures. That's why I have focused on the youngest children, they don't yet have a full grasp of language and so respond well to picture books. I think taking this type of visual approach can work just as well in communicating to adults and older children.

Climate science in particular is all quite abstract, $CO_2$ levels and that sort of thing is invisible. I think that is one of the reasons that we the public aren't responding to the urgency of this problem.

**Emily:** I'm always keen to find new and innovative ways of engaging with different audiences around our scientific research – Trans.MISSION project is a fantastic example of this.

**What's been the biggest surprise?**

**Chris:** All the work they are doing is so interesting, it is incredible to think they are drilling 3km down into ice that fell as snow 800,000 years ago. It's fascinating.

**Emily:** I have thought a lot about how to communicate climate science to a general audience, but I was very excited to hear Chris' thoughts on how to do this.

**What's been the best moment?**

**Chris:** Going into the freezer in Cambridge with Emily and looking at 140,000 year old ice.

**Emily:** Chris came to visit the British Antarctic Survey where I took him into the ice core freezer to actually hold some ice core samples. He could listen to the bubbles of air, tens of thousands of years old, that are frozen in the ice and pop as the ice starts to melt. I was able to explain to him how analysis of the ice cores provides us with a history of our past climate.

**What's been the most difficult?**

**Chris:** Trying to condense all this into a few simple points.

**Emily:** Trying to pick which areas of climate science to highlight.

**What do you hope people will take away from seeing your piece?**

**Chris:** Ideally I would love this to be a very short entertaining explainer on climate change that could be easily understood and shared on social media. I hope people can understand something more about the fascinating research behind it all.

**Emily:** I hope people will gain some insight into the excitement of doing scientific research and the importance of the findings for understanding the future of our planet.

**Would you work with a scientist/an artist again?**

**Chris:** Yes! I would love to.

**Emily:** Yes, of course!

**What have you learnt about each other's work?**

**Chris:** One of the things I have learnt from our conversations is how easily research can be misunderstood. It must be extremely frustrating.

**Emily:** Chris has a fantastic ability to take a complex topic and reduce it to a simple and clear but nevertheless comprehensive message.

**See Trans.MISSION 1:**
**Polar Science and Climate Change**
26 May 2018, 5.30pm
*Tickets:* www.hayfestival.org

# Dan Binns and Professor Ally Lewis

Aardman Animation Studios' director Dan Binns paired up with Ally Lewis, atmospheric chemist at the National Centre for Atmospheric Science (NCAS) and the University of York. Dan is a Commercials director at the multi-award-winning studio, creators of Wallace and Gromit. They have collaborated to create an original piece of work that will explore the issues around air pollution.

**What made you interested in doing this project?**

**Dan:** The chance to learn something new.

**Ally:** Sounded like something a bit out of the ordinary, and maybe a way to talk to a different audience about an aspect of air pollution that hasn't been much covered before

**What's been the biggest surprise?**

**Dan:** How easy the subject matter was to understand when you have a very knowledgeable scientist on hand to answer your questions!

**Ally:** That other people are actually interested and surprised by the research. I spend my whole life working on this topic, so I have obviously convinced myself it's worthwhile, but it's very hard to judge what anyone in the real-world thinks.

**What's been the best moment?**

**Dan:** Seeing a conversation turn, albeit slowly, into something concrete.

**Ally:** Telling my kids that I was doing something with Aardman, although they were disappointed that there wouldn't be a small plasticine version of me at the end of it.

**What's been the most difficult?**

**Dan:** To remember to focus on the things that make a film engaging and not get lost in the science.

**Ally:** Knowing what detail to leave in and what to leave out. Volatile organic compounds as air pollutants aren't straightforward. There are thousands of different compounds to start with then each undergoes thousands more reactions before it becomes a nasty like ozone or particulate matter. The detail in the middle matters to chemists, but perhaps not to everyone else, so keeping the story simple is a challenge.

**What do you hope people will take away from seeing your piece?**

**Dan:** The ideal outcome would be getting the viewer, just for a moment, to consider the products they buy and the effect they can have.

**Ally:** That there is more to air pollution than cars and exhaust pipes, and that a surprising quantity of emissions come from the home. Managing these is surpassingly easy – simple actions in the home go a long way. And individuals directly benefit with improvements in the air quality inside their homes.

**Would you work with an artist/scientist again?**

**Dan:** Definitely. I think trying to take scientific research or discovery and communicate that to a mass audience is a pretty good use of animation or film-making. From a creative point of view it's an enjoyable challenge to do that in a concise and entertaining way that doesn't simplify so much it loses all the science.

**Ally:** Definitely.

**What have you learnt about each other's work?**

**Dan:** That it's incredibly interesting. That he works in an area I would have assumed would be more widely discussed and that the practical aspects of the job are, in his words, a 'bit unglamorous' (a lot of sitting in shipping containers and running experiments I think!)

**Ally:** I've seen really interesting ideas of visualising pollution in ways wouldn't have thought of. I'm looking forward to seeing how the styles and ideas translate into animation – not an obvious step for me.

**See Trans.MISSION 2:**
**Clean air**
28 May 2018, 7pm
*Tickets:* www.hayfestival.org

# Nicola Davies and Professor Ed Hawkins

Nicola Davies has been working with climate scientist Professor Ed Hawkins from the National Centre for Atmospheric Science (NCAS) and the University of Reading. Ed focuses on improving predictions of climate change and its impacts and Nicola has authored more than 50 books for children: fiction, non-fiction and poetry. They have collaborated to create an original piece of work that will explore the issues around extreme weather events.

**What made you interested in doing this project?**

**Nicola:** As a zoologist turned writer I leapt at the opportunity to work with a different sort of scientist, especially one who is working on climate and weather. I wrote a book for young people about climate change almost a decade ago and I was interested to revise it and think about new ways to communicate the information. Ed has the most wonderful visual sense so in one way it's rather like working with an illustrator.

**Ed:** It is an amazing opportunity to work with a talented author to help communicate the risks of our changing climate to a different audience. Climate change will affect all of us and it is essential that we seek a wide variety of perspectives about how to tackle this problem.

**What's been the biggest surprise of this project?**

**Nicola:** The stories. I've loved hearing about the weather recorders and their absolute devotion to collecting accurate data (especially the Ben Nevis weather watchers)…Many are and were keen amateurs. I love the idea that every point on one of Ed's graphs is the synthesis of the efforts of so many people, a weaving together of moments in so many lives.

**What's been the best moment?**

**Nicola:** Not sure yet too early to say…but I think meeting Ed and feeling that he was really approachable and easy to talk to (I was nervous) and saw things in a similar way to me.

**What's been the most difficult?**

**Nicola:** My brain hurts a bit looking at some of the data representations. Even when I was a scientist I was never any kind of statistician and some of them I still don't understand (Ed will be rolling his eyes reading this point I'm sure).

**What do you hope people will take away from seeing your piece?**

**Nicola:** Both Ed and I want to get across the difference between climate and weather, and how apparently small shifts in average temperature – climate – can make big difference to the sort of weather we experience. Predictability is a big part of what people rely on with weather, even in the UK's crazy all weathers in one day climate. So there will be some playful interactive activities around weather climate and event planning. But also that climate change isn't a done deal – the power to change and turn things around is in our hands. It's vital to seize it and not to feel powerless. I really want people to enjoy our event – to laugh, to think and maybe to go away with a few portable couplets in their heads…

**Ed:** I hope that people will better understand how our climate is changing and start conversations about how individuals and the world might best address the issues. Our choices will affect the weather that future generations experience.

**Would you work with a scientist/an artist again?**

**Nicola:** Collaborations are always wonderful…always great to learn about someone else's work and look for similarities and differences. Really shores up the creative batteries.

**Ed:** Definitely!

**What have you learnt about each other's work?**

**Nicola:** The thing I've learnt so far is that Ed is utterly committed to explaining what he does to the world, so as many people as possible understand it. The reason I left an academic career behind was that I felt it would be preaching to the choir…but Ed has shown me that that is absolutely not true.

**See Trans.MISSION 3:**
**Extreme weather events**
29 May 2018, 7pm
*Tickets:* www.hayfestival.org

VISIT OPERATION EARTH

*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 breech 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.

VISIT OPERATION EARTH

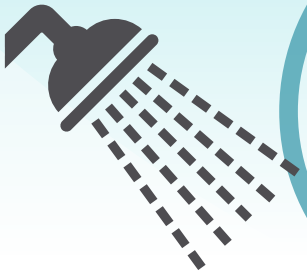
# On the way to **plastic-free oceans**

*Written by* **Sylvie Kruiniger**

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.

The trouble with these useful little beads is they're so small they slip though 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 Proctor & Gamble. The ban will not apply to products that you leave on your skin such as suncream and make-up.

### The bigger plastics picture

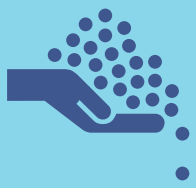
Katsiaryna says: "The microbead ban is a wonderful step forward. But they are an important part of a much bigger picture. There are so many items, especially in the UK that we use only once before throwing away. Over time, things like bottles, carrier bags and toys all break down into smaller pieces.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

**http://bit.ly/EACplastics**

## What can I do?

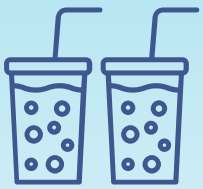


### Join the great nurdle hunt

Look out for these tiny, lentil-sized plastics on beaches and report your sightings.
**www.nurdlehunt.org.uk**

### 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/**

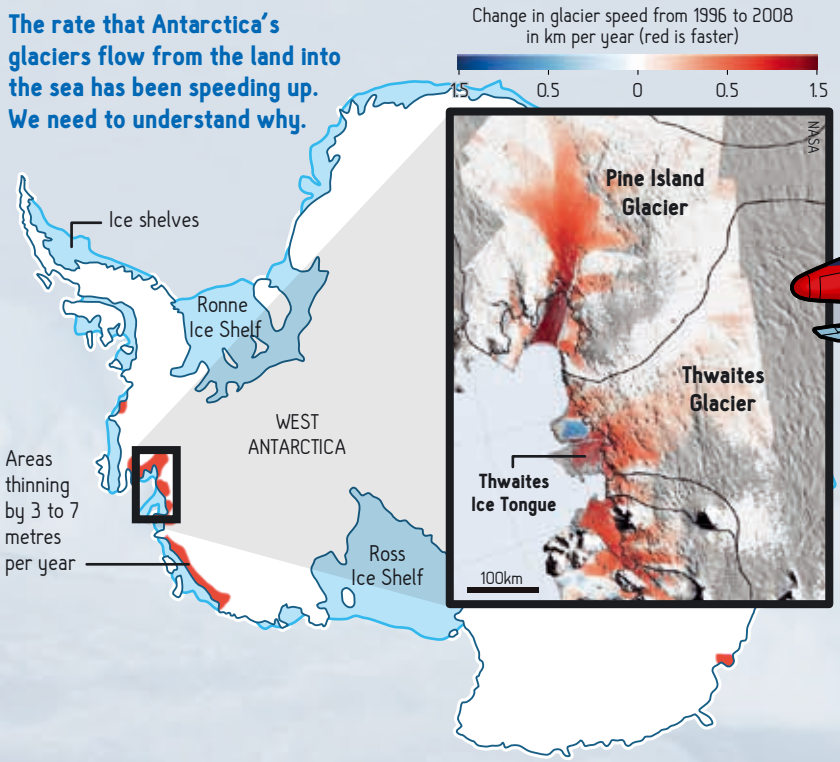


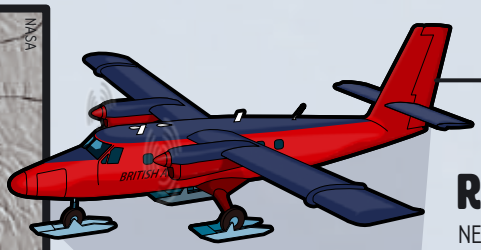
### Use less plastic

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

# 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

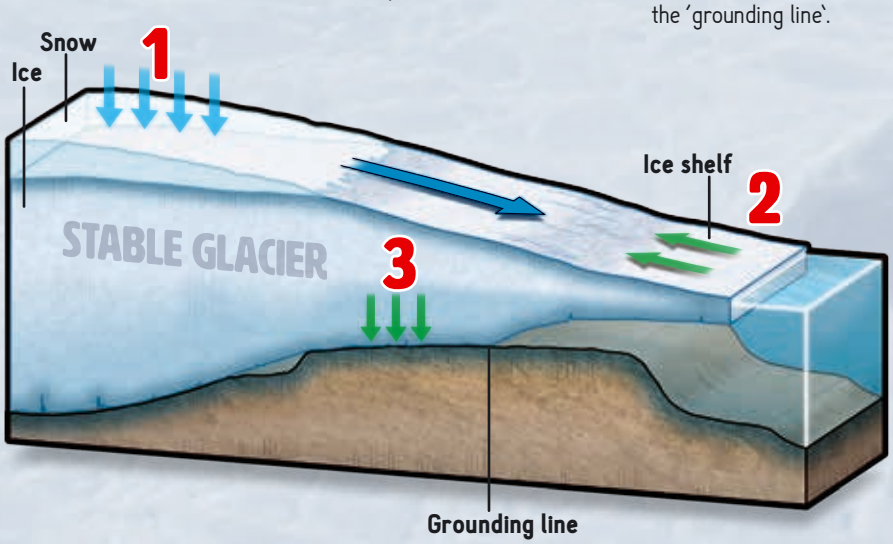
NERC's Twin Otter aircraft will take radar measurements to look deep below the surface of the ice and build a clear picture of how different layers of ice and the bedrock interact. This is crucial in understanding how climate change will affect large ice sheets.

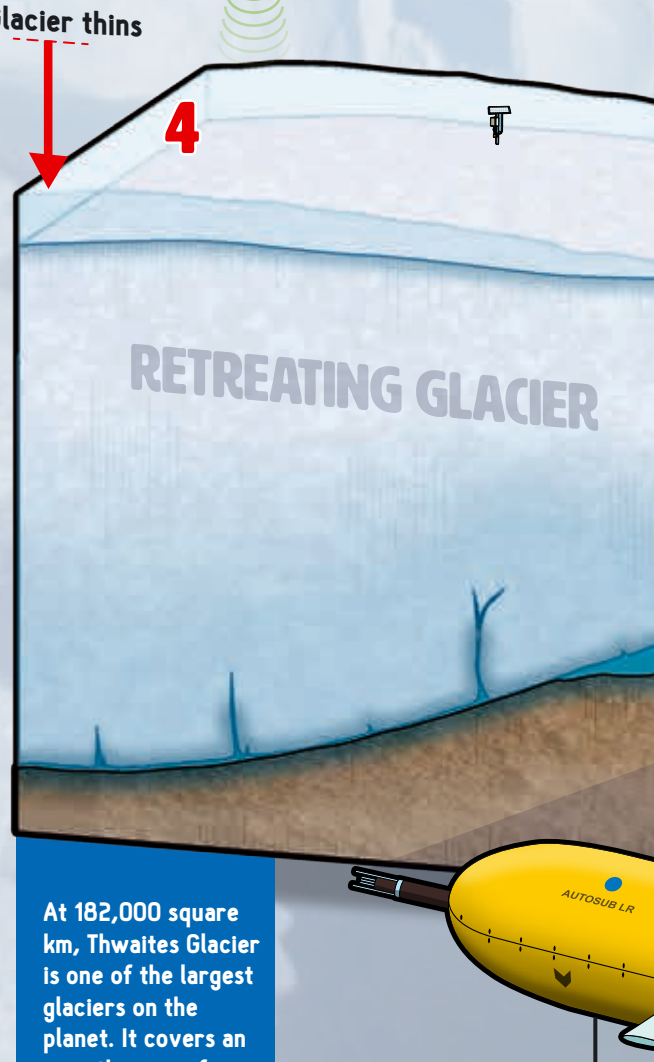
## FROM STABLE GLACIER...

**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'.




## ...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.**

NERC SCIENCE OF THE ENVIRONMENT

NSF

## 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.

## 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.

## SEISMOMETERS

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

## 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.

Glacier flow accelerates

Iceshelf retreats

7

6

5

Warm currents

Grounding line retreats

Between 1992 and 2011 the 'grounding line' where the Pine Island Glacier's ice connected to the land retreated 30km and Thwaites' retreated 15km.

## 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.

# 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 Hitchhikers 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.

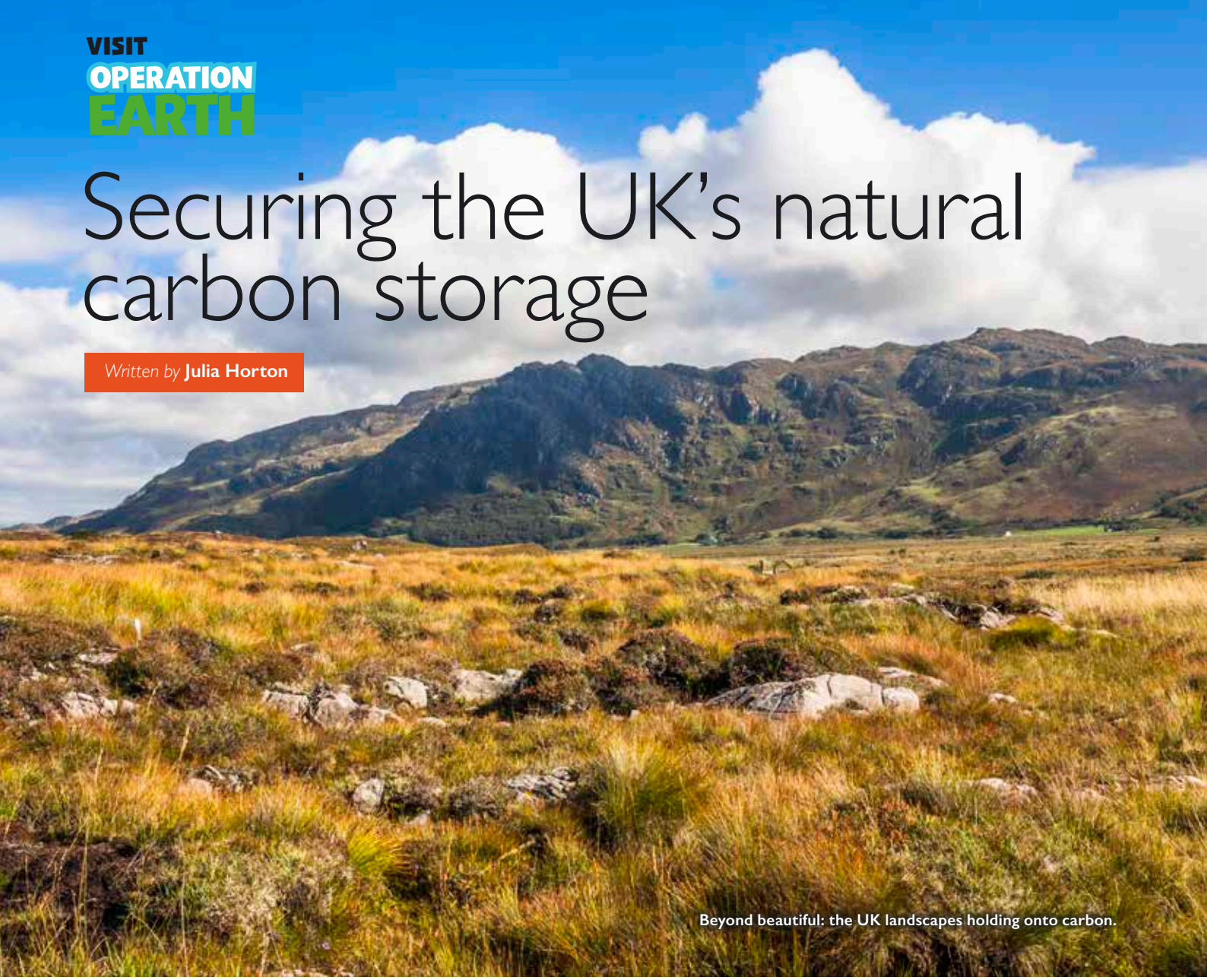
Longer term, the Condatis website will let charities around the world share invaluable information on how they are using the software – perhaps finally providing the answer to conserving life on earth, if not quite the universe and everything else.

Find out more on the Condatis website: **wordpress.condatis.org.uk**

VISIT OPERATION EARTH

# 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$^2$ compared to 17,270km$^2$ – 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

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**

VISIT OPERATION EARTH

Using every inch. How do we keep people fed as populations explode and good farmland dwindles?

# 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. 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.

## 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, reseachers and industry to transform food production.

Find out more at **http://bit.ly/transformingFP**

### 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**

VISIT OPERATION EARTH

# 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."

**Professor Lisa McNeill helps carry a core from the sea bed.**
Tim Fulton, IODP JRSO

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

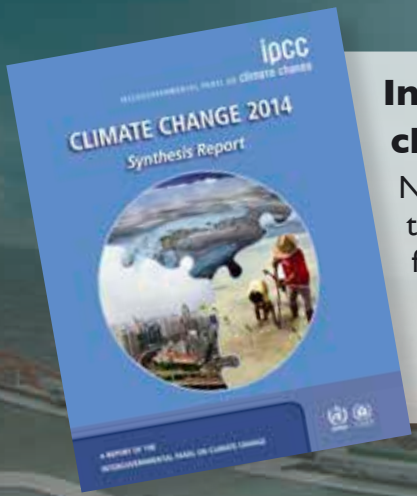
By drilling deep beneath the ocean, IODP expeditions extract samples of ancient sediments and rocks, which contain a detailed record of how the planet has evolved over millions of years.

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.




## 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 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."

## 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.

JAMSTEC IODP

Tim Fulton, IODP-JRSO

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

VISIT OPERATION EARTH

# 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

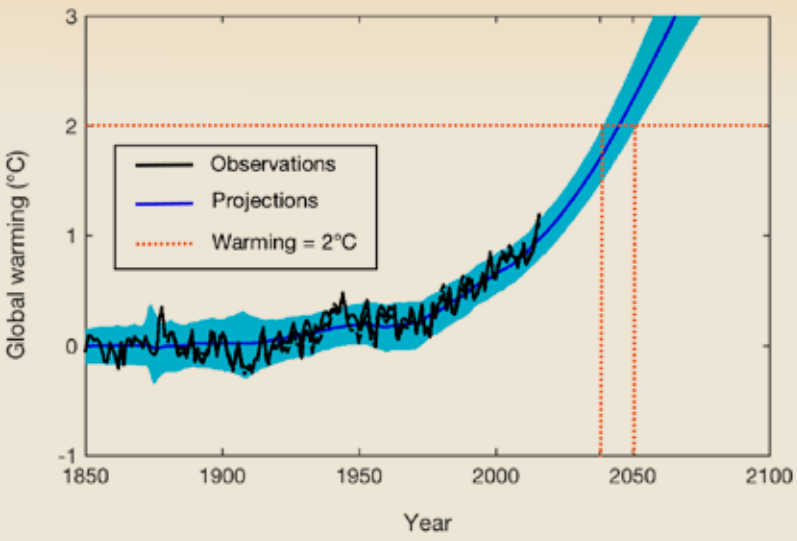
To develop a more carbon-efficient and ultimately carbon-neutral future, we need to develop and adopt new technologies, and plan and organise our societies to use energy more efficiently and reduce carbon emissions. We also need to explore ways of capturing carbon to reduce how much carbon dioxide is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

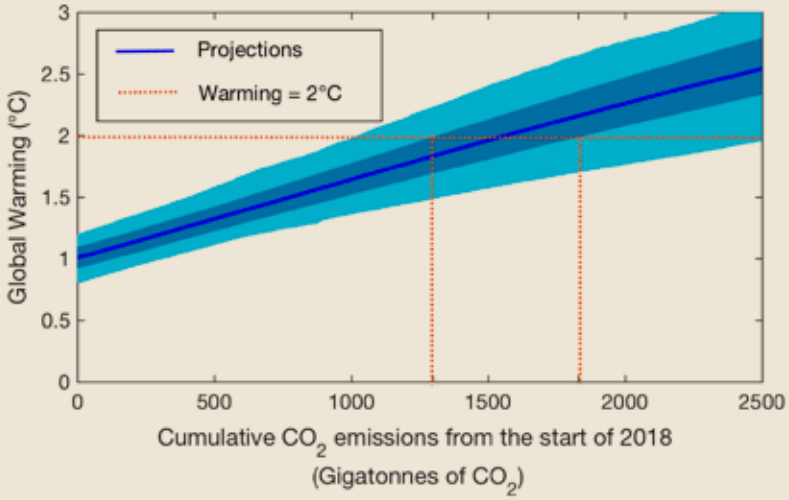
We all face challenges in making this transition, but the earlier that we start moving towards a more carbon-efficient future the easier it will be to meet these warming targets.

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**

# OPERATION EARTH

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NERC SCIENCE OF THE ENVIRONMENT

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