

Taking the long view

It may not be 'blue-skies work' or 'cutting-edge research', but long-term monitoring has produced some hugely important – and highly influential – science. **Becky Allen** looks at some of the world-class long-term monitoring NERC funds.

Hindsight is a wonderful thing. When the British Antarctic Survey (BAS) began monitoring ozone levels over Halley Research Station in Antarctica during the 1950s, nobody knew that 30 years on the data would reveal the hole in the ozone layer and pave the way for one of the world's most successful international agreements – the Montreal Protocol.

Together with US measurements of carbon dioxide at Mauna Loa – dubbed the most important geophysical record on Earth because it alerted the world to climate change – BAS's ozone record has become an iconic example of the value of long-term monitoring.

Today, according to the Environment Research Funders' Forum (ERFF), the UK invests at least £250 million a year in environmental observations on land, sea and in the atmosphere. From levels of pesticides in birds of prey to natural variation in the Earth's magnetic field, much of our knowledge about planet Earth and our

impact on it comes from long-term studies (LTS). So what does NERC fund, why are these studies so valuable, and what's it like working on science that may take decades to yield reliable results?

To a large extent, we invest in LTS because there's no alternative. In a world of quick fixes, LTS remain the only way to understand complex, highly variable natural systems.

Sea-level rise is a good example. According to Dr Simon Holgate of the Proudman Oceanographic Laboratory (POL), 'We need high-quality data collected over a long period of time to understand changes in sea level – because change in sea level is noisy, you need at least 60 years of data.'

Holgate works on the Permanent Service for Mean Sea Level (PSMSL). Set up in 1933 and hosted by POL to collect data from several hundred tide gauges across the world, PSMSL's data now run to over 54,000 station-years from around

2000 stations and are crucial for national and international policy on climate change adaptation, including work by the United Nations Intergovernmental Panel on Climate Change.

Ecologist Professor Steve Ormerod of Cardiff University, whose research includes monitoring how well 14 Welsh upland streams have recovered from acid rain over the past 25 years, believes climate change makes LTS more relevant today than ever. 'The value of LTS is increasingly important

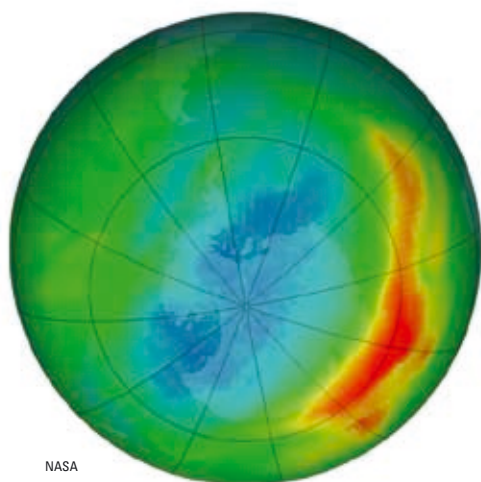
These measurements are our insurance.

in an era of rapid environmental change. How can you assess global environmental change without long-term research?' he says.

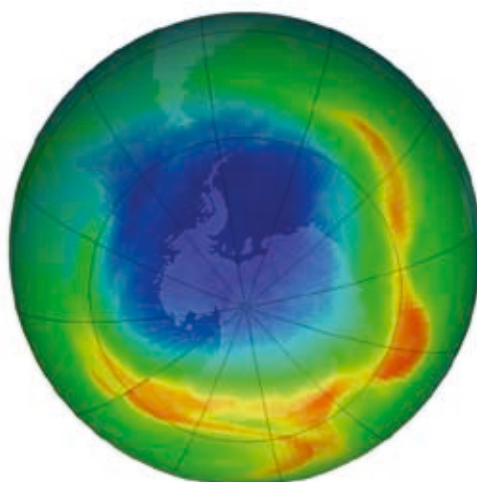
And while models are increasingly useful for assessing the impact of climate change, their accuracy and reliability rest on the

Changes in the ozone hole over a 30-year period.

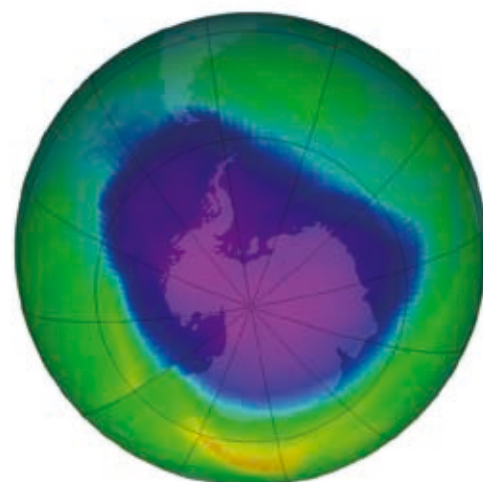
September 1979



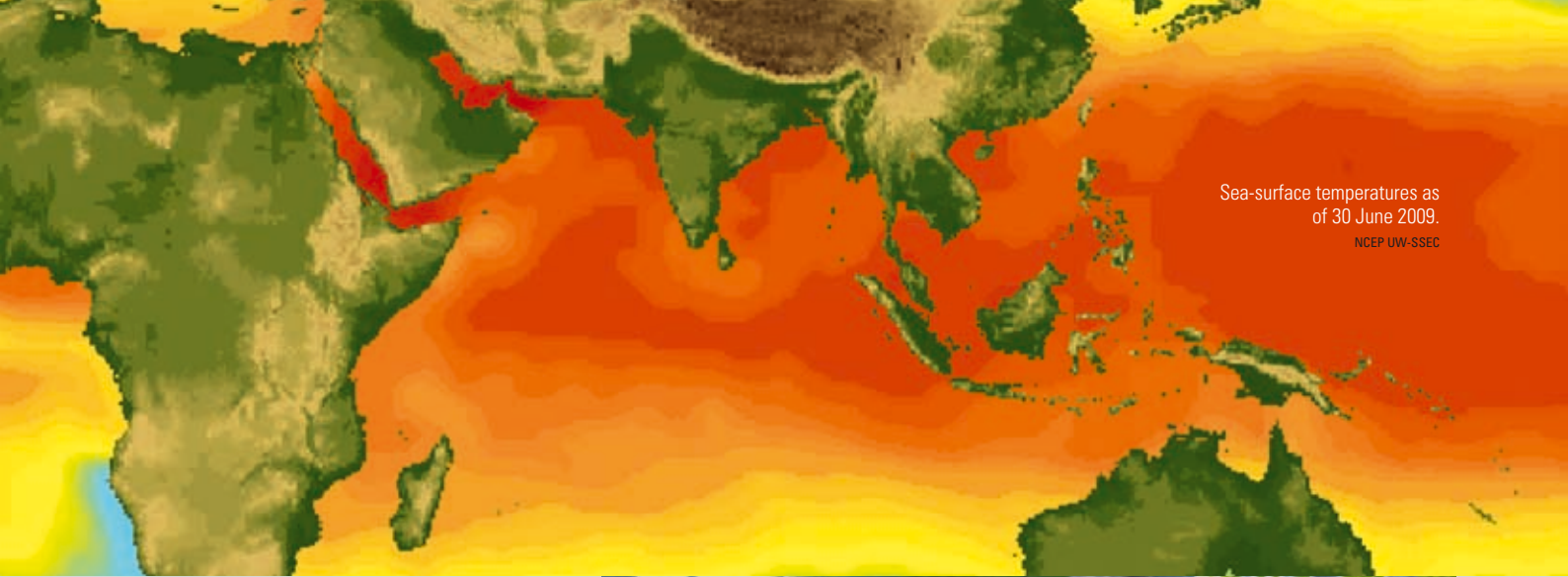
September 1988



September 1998



NASA



Sea-surface temperatures as of 30 June 2009.
NCEP UW-SSEC

quality of data fed into them – data that comes from LTS.

According to Professor Alan O’Neill of the National Centre for Earth Observation, ‘Environmental monitoring is like monitoring the vital signs of a patient. We need that monitoring to provide a diagnosis, to say what causes the changes we are seeing, to test the models we are using and as the basis of their predictions. LTS are fundamental tests for climate models – our confidence in their predictions rests entirely on long-term data.’

Unlike new satellite projects such as Global Monitoring for Environment & Security (GMES) (in which the UK is investing £82 million), early missions weren’t designed with long-term datasets in mind, but many satellite records from the past 40 years have been stitched together to provide important evidence on climate change.

‘The big debates on atmospheric temperature responding to climate change



TIMBER!

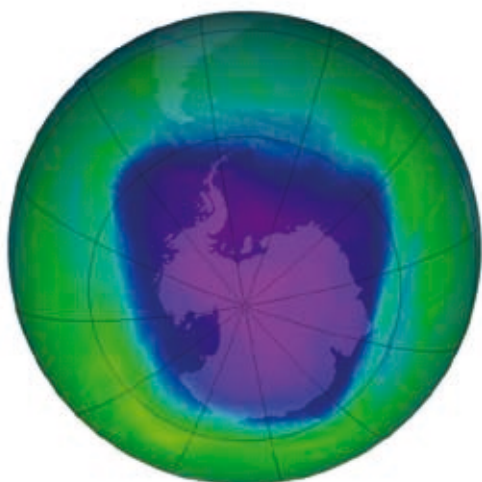
Part of a large team of scientists involved with the African Tropical Rainforest Observation Network, Dr Simon Lewis of the University of Leeds turned 40 years of run-of-the-mill forestry data into ground-breaking science published this year in *Nature*.

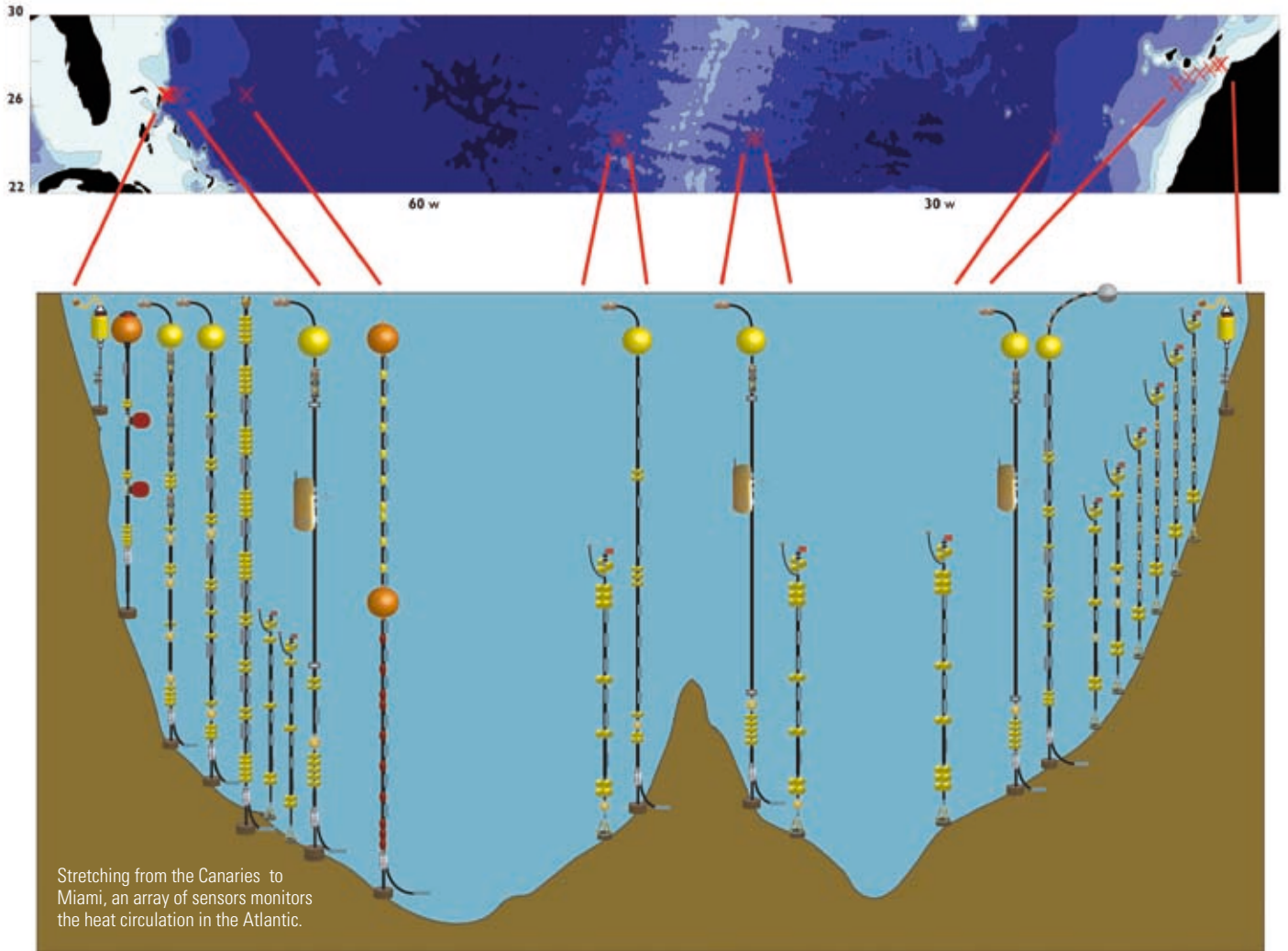
Using skills that would have impressed Sherlock Holmes, Lewis tracked down long-term records from 70,000 trees in 79 one-hectare plots across ten African countries. His results showed for the first time that tropical forest trees account for around half of the carbon absorbed by land-based sinks. The study is another example of the serendipity of long-term data.

According to Lewis, ‘We are reliant on a historical accident, but it’s still incredibly valuable. No one started this looking to monitor the effects of global environmental change. But that’s what these data have ended up contributing to.’

As well as helping answer a crucial climate-change question, Lewis says the work is helping build capacity in African ecology. ‘Our studies have highlighted the local importance of this sort of data. It’s helped them get funding to maintain and expand the monitoring. Local African ecologists and botanists are now more in demand and their experience is more valued.’

September 2008





have been put to bed by satellite data, and satellites have given us fundamental information on how sea-surface temperature is changing regionally and globally,' O'Neill explains.

Reaching the parts other studies cannot reach

Compared with terrestrial systems, past technical and logistical barriers have meant that LTS from the world's oceans are few. Some projects, like the venerable Continuous Plankton Recorder, have been able to gather long-term data by partnering with commercial shipping. New technological developments, however, have spawned a new generation of NERC-funded LTS that are plugging important gaps in knowledge on the oceans' role in climate change.

Since 2004, the UK-led Rapid Climate Change programme has been monitoring the Atlantic Heat Conveyor – the huge ocean circulation that moves heat northwards from equatorial waters – via three arrays of sensors along latitude 26.4°N between the Canaries and Miami. According to Dr Craig Wallace of the National Oceanography Centre, Southampton, 'We

decided that ten years' data was an absolute minimum to detect any rapid slowdown. So far we know the system is highly variable day to day. That's a world first. We have four years of cleaned and calibrated data to see if there's a trend up or down. So far we've not seen any, but the telling time will be in 2014 when we have ten years' data.' NERC will then decide if the sensors become part of the UK's long-term climate and weather monitoring capability.

Another newcomer to the long-term monitoring scene is the Cape Verde Atmospheric Observatory, part of a UK-German initiative begun in 2006 to make year-round observations of the atmosphere in this remote region of the tropical Atlantic Ocean.

Although ship-based measurements have been made in the past, the data is too sparse to provide an early-warning system and improve climate models. As Professor Alastair Lewis, Director of Composition Research at the National Centre for Atmospheric Science (NCAS) explains, 'It's a key place because it acts like an engine room for cleaning up the atmosphere, so we are monitoring that self-cleaning capability long term to see whether it's changing.'

But it's not only climate change that is the focus of NERC-funded long-term monitoring. Set up in 1962 – the same year that Rachel Carson's *Silent Spring* was published – the Predatory Bird Monitoring Scheme (PBMS) is now the longest-running record of its kind in the world.

The PBMS analyses contaminants in species such as sparrowhawks and red kites. Over nearly five decades, it has monitored levels of organochlorine pesticides, PCBs, mercury and other chemicals in these birds' tissues. Its archive – worth around £4 million – contains some 40,000 tissue samples and 10,000 eggs, representing a unique capacity to determine long-term trends in other chemicals that may in future be recognised as posing risks to wildlife.

Of current concern, says Professor Richard Shore of the Centre for Ecology & Hydrology, are so-called second generation anticoagulant rodenticides (or rat poisons to most of us). 'We have found that rodenticides are widespread contaminants in the food chain, present in a large proportion of many species. Industry argued that it was a small problem, but we've found it's a big issue,' he says.

Based on this data, PBMS has been able

All points north

When it comes to long-term data, geologists interested in geomagnetism like Dr Alan Thomson from British Geological Survey (BGS) count themselves lucky.

Sporadic data goes back to the 17th century, and magnetic fields have been monitored continuously in the UK for over 160 years, with magnetic observatories set up in Lerwick, Eskdalemuir and Hartland measuring its strength and direction since the early 1900s.

According to Thomson, 'The value of being able to look back more than 100 years is something not many sciences have. It shows how much the sun can affect us, not just heat and light but magnetism.'

As well as deepening our understanding of long-term change in the Earth's outer core, the more than 250,000 daily 'magnetograms' held by BGS have wide practical applications in the oil industry – where they are used for navigating well bores, and for predicting space weather events that can damage electricity power grids and telephone communications as well as satellites and spacecraft.

One of BGS's most sought-after records is from 1 September 1859, when a violent solar eruption and geomagnetic storm occurred – the so-called Carrington flare event – that would have wrought havoc with power grids and satellites had they existed then. Even 150 years on, researchers remain fascinated by whether this was a one-off occurrence.

It's one of the things that for Thomson makes working on LTS so fascinating, 'One of the payoffs of doing this kind of work is that there are unforeseen consequences – people find new things in old data all the time.'



The Cape Verde Atmospheric Observatory.

to work with the Campaign for Responsible Rodenticide Use – the industry body – to educate users about how to avoid poisoning wildlife. Its data also provides a benchmark against which to assess the success of the campaign.

Patience is a virtue

As well as LTS' pivotal role in understanding environmental change and for putting the 'evidence' into evidence-based policy, many researchers involved with long-term datasets argue they have far wider benefits. Most often mentioned is their ability to act as early-warning systems and to throw up serendipitous findings.

According to O'Neill, 'We need a safety net, a certain spread of measurements. If we have a sufficiently broad spread we will pick up shadows or suspicions of things like the ozone hole. These measurements are our insurance.'

Because of their longevity, they can also act as catalysts for other, short-term studies. According to Ormerod, 'Flagship LTS sites attract lots of scientists to look at many simultaneous changes, and are often a focus for smaller scale experimental studies too. This 'nesting' of research means LTS often provide opportunities for other scientists.'

They are ideal vehicles for interdisciplinary research too, he says, 'Our acid-rain study is fabulous because it links atmospheric science, local meteorology, soil chemistry, geology, ecology and hydrology – the complete remit of NERC science is there.'

And because the biggest gaps in our datasets are in the southern hemisphere, LTS like the Cape Verde Observatory – which is staffed by local labour – provide

important opportunities to build science capacity in underdeveloped countries.

But LTS face significant challenges too, not least in securing long-term funding. O'Neill says, 'It's very hard in a dynamic research environment to sustain long-term observations because people are averse to making long-term commitments.'

Making the case for funding is crucial, says Susan Ballard of ERF, which is mapping out 'a fantasy football team of observations' from which to decide on priorities. 'The environmental research community must be able to tell the Treasury how much we are spending and what the return is on this investment,' she says.

While certain benefits are relatively easy to quantify, others are less tangible. Scientists and policy-makers today benefit from a legacy left by earlier generations. O'Neill believes current generations should leave a similar legacy, 'We must try to provide the best possible information now for future generations' decisions.'

Researchers working on LTS also need support as well as funding, Lewis believes. Once Cape Verde was up and running he suddenly realised he was in for a long stretch. 'It's like painting the Forth Bridge,' he says. 'It's very daunting. It relies on a huge commitment, especially from younger scientists where paybacks may not occur during their academic tenures ... It needs a big vision from individuals and organisations.' ♦

MORE INFORMATION

Becky Allen is a freelance journalist specialising in science and environmental issues, email: beckyallen@ntlworld.com