Fire wire harnessing the power of the intern

How are environmental researchers exploiting internet technologies? **Ned Garnett** discusses the *e*Science programme.

The internet has fundamentally transformed how scientists do research, whether it is accessing data, using that data, or simply communicating with colleagues. NERC's £14.2 million *e*Science programme, which began in 2001, investigated ways for environmental scientists to make the most of new internet-related technologies, particularly in Earth system and climate modelling, visualising large datasets and mineralogy. Seven years on, the programme can take credit for many scientific and technological advances. Some researchers say the programme has completely changed how they work. But its influence goes beyond the environmental research community. In April, a major international conference at the Royal Society in London will demonstrate its full impact.

The former Director General of the Research Councils, John Taylor, originally coined the term *e*Science in 2000. He recognised that the internet explosion would transform the way researchers do science and he wanted to ensure that the UK played a leading role.

NERC's *e*Science programme, part of a larger cross-council programme, brought researchers from the atmospheric, marine, polar, freshwater, earth and biological science communities together with computer scientists. This disparate group looked at how to do new and innovative environmental science using the rapidly developing internet technologies and other distributed computer systems.

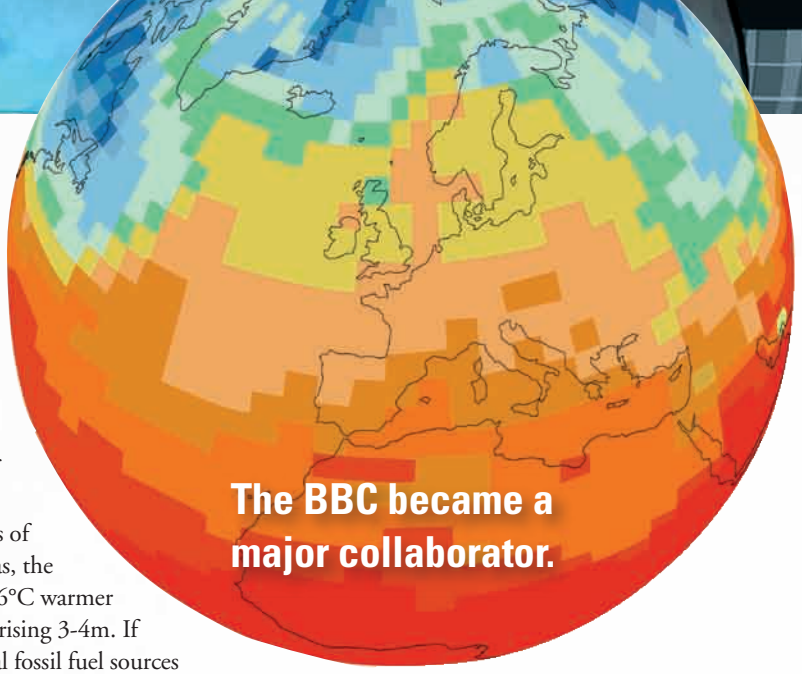
Scientists can apply the same technology to other issues such as flood prediction and oil-spill mitigation.

Many key questions facing environmental scientists are at scales that do not lend themselves to conventional experimental science. We do not have a spare planet to look at the effects of different concentrations of greenhouse gases or indeed a time machine to look at what will happen in the decades to come. And it is not possible to observe at a molecular level exactly how pollutants bind to the surface of soil.

Traditionally, researchers construct computer models of how these key processes work and then run the models to predict what would happen in certain circumstances. Running these models requires a massive amount of computer processing on costly supercomputers which are in limited supply. The *e*Science programme has gone for a different approach. It has developed ways of exploiting the power of smaller computers both by developing a grid of computers in different institutions and by harnessing the unused processing power in home and business PCs.

There were many highlights in the programme. Here I will discuss four.

et for environmental research



The BBC became a major collaborator.

Going global

By far the most high-profile project to date has been climate*prediction*.net. This project took a method originally employed in the search for extraterrestrial life (SETI@home) to use idle computers in homes and offices to forecast climate.

The internet allowed the team to do ensemble climate modelling. This is where the researchers run exactly the same model over and over again, each time subtly altering one of thirty key model parameters. The main advantage of this approach is that it allows researchers to quantify uncertainty. Instead of stating categorically that the world can expect temperatures to rise by a certain amount, which is unrealistic because there are elements within the system that are intrinsically variable, the scientists can state the range of temperatures, and crucially, the likelihood of each one.

The BBC became a major collaborator. This helped raise the profile of climate research and improved public understanding of the nature of uncertainty.

The project has been extremely successful: over 300,000 people have downloaded the software to date.

Thousand year climate models

As well as large-scale ensemble models, climate researchers can also use a different type of distributed computing to look at Earth's climate thousands of years ago. This increases knowledge of how climate has changed naturally in the past. The GENIE team (Grid ENabled Integrated Earth system modelling) and colleagues used their climate models and grid computing resources to simulate the climate and carbon cycle through the last ice age cycle. By comparing the models with past climate data, the team can constrain how the models represent key processes, improving confidence in future projections.

The same team used grid computing to see what the climate could be like 3000 years from today. The Environment Agency commissioned the work to help plan for the future. This research helps answer questions like how will the coastline change? And, where is the safest place to build nuclear power stations?

The study revealed that if we burn the known reserves of coal, oil and gas, the world will get 6°C warmer with sea levels rising 3-4m. If unconventional fossil fuel sources are also exploited, the GENIE model demonstrated that it could get over 10°C warmer causing a complete meltdown of the Greenland ice sheet, collapse of global ocean circulations and a sea-level rise of over 10m.

The team's models show that by globally achieving a 60 percent reduction in carbon dioxide emissions by 2050, followed by a complete stop in emissions by 2200, we might protect Greenland from melting and restrict global warming to 1.5°C.

Saving lives

Many industries and services need accurate weather and ocean forecasts to make decisions. For example, when a yachtsman falls overboard, coastguards use forecasts of the winds and ocean currents to predict the drift patterns of both the stricken sailor and the yacht. The DEWS project (Delivering Environmental Web Services) brought together the Met Office, NERC *e*Scientists and software writers to develop a better forecast system for coastguards and the healthcare sector. It has already proved successful for both these users. In healthcare, medical conditions such as Chronic Obstructive Pulmonary Disease account for five percent of all deaths globally (as many as Aids) and is worsened by specific weather conditions. The DEWS project allows forecasters to provide adequate warnings of approaching conditions that could be deleterious to health. Scientists can apply the same technology to other issues such as flood prediction and oil spill-mitigation.

Molecules online

The *e*Minerals project used computer simulations to increase knowledge of a range of environmental processes at the molecular scale. The work included analysis of how pollution moves through soils and groundwater; long-term encapsulation of nuclear waste; minerals in the inner Earth; and how minerals and fluids interact. The challenge was to exploit grid computing to undertake these very large calculations and to manage the deluge of scientific data generated in such studies. The team now has a better understanding of the forces governing how toxins interact with soils, which will eventually help develop effective land-remediation strategies.

The future

NERC's new strategy states that 'NERC aims to remove barriers to help environmental research take place effectively and efficiently'. *e*Science is an extremely effective way of achieving this goal. The programme has already developed communication tools for teams working in different laboratories, new methods for sharing data, and computational tools that are radically changing the way that scientists in different institutions and in different disciplines work together.

For the first time, NERC's new strategy identifies technology as a specific science theme. This recognises the central role that technologies such as *e*Science will play in advancing environmental science in the future. The *e*Science programme puts NERC firmly at the cutting edge of these new technologies. The challenge now is for the environmental research community to adopt more widely the new tools and systems developed by the programme. ✿

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