Ecosystems: modelling the Earth

Using a model

Dr Neil Edwards:
I'm Neil Edwards. I'm in radio and air systems science at The Open University and what I'm particularly interested in is using numerical models to understand the Earth system. I've come to Southampton to meet a man who's hoping to model the whole Earth system. It's an ambitious project and a difficult one. But what will it tell us if we can't find out through observation? Why do we need models at all? I'm hoping John Shepherd will be able to tell me.

Prof John Shepherd:
The interesting thing about the Earth's system is that almost everything interacts with almost everything else so let's think about plants, for example. Plants interact with animals because animals eat them, but they also interact with the atmosphere because they get CO_2 and water vapour, but the atmosphere interacts with the ocean, a lot of exchange of water vapour and heat between the atmosphere and the ocean, and they both move stuff around the planet, so as soon as you start to explore this system you realise that the atmosphere and the ocean, and the land surface, and the ice caps and outer space are all relevant and need to be thought of together, and we that we need to think about the physics of it, the chemistry of it, the geology of it, the biology of it, and how it all works, and really you very soon come to the conclusion that you should have a model of the whole thing, even if it's not very detailed. We can measure the present climate, sure. To some extent we can measure the past climate, although with very much more difficulty if we go back beyond the instrumental record, which only starts in the 19th century. In the future we can't measure that, and we are interested, not only in the past, we're interested in the past as a guide to the future.

Dr Neil Edwards:
John's got a very simple Earth system model running on his lap top so we went to see how it works.

Prof John Shepherd:
This is it, this is GENIE, and it's been nicely encapsulated for the students to use. You can see that the model is actually made up of a bunch of little squares, little grid squares, and actually levels in the ocean as well, so it's all a bunch of little boxes and fundamentally stuff moves from one box to another. It could be water, it could be air, it could be nutrients, it could be heat, and just to make something interesting happen we can actually change here the rate at which leaf litter is turned over in the model. Now it's started to re-run and we will see the temperatures rising, I think, is my prediction for this. There's always a good thing to do with a model is to make a prediction of what you think it will do and then see if the model does what you expect. And there we go, the temperature's rising, see, the summer temperature is in Year 2 is already higher than it was in Year 1, and what is happening here is that North American land temperature in the summer is going up by about a degree, yeah, that's a really very serious climate change.

Dr Neil Edwards:
It always does. That's quite a drastic effect on global climate.

Prof John Shepherd:
Just by changing a parameter that affects what leaves are doing in forests and soils, and it's a good example of the way everything is connected. We can learn a great deal about the behaviour of the model world, but you can still see that the continents are a bit lumpy.

Dr Neil Edwards:

Spain is just one grid cell.

Prof John Shepherd:
Spain is one grid cell. The UK doesn't even show up as a separate grid cell at all, so although we can see where Africa is and we can see where Asia is, we would really like to have a bit more geographical discrimination, and that costs money, and I don't have a super computer in this room, but I do have the results of some model runs on a super computer with a much more detailed model. This is now a model called OCCAM for Ocean Circulation and Climate Advanced Model. We have got the marine biosphere working in here so we can see plant production, primary production in the world oceans. We can see very nicely how the primary production moves north and then subsequently south again with the seasons. This is data from the SeaWIFS satellite of the greenness of the ocean seen from space and greenness, of course, corresponds to chlorophyll and ultimately to plants. We can see the same pattern of primary production moving north and then south, and we can not only look at the pictures and see that they correspond, we can actually take numbers and compare the numbers, and see quantitavely how well does this model fit the real world data, because that is the acid test of the model – does it represent reality?

Dr Neil Edwards:
So John showed us that we can understand more about the limitations of models by comparing them with data, but that difference between what the models say should happen and what the data says actually does happen is model error, and if we want to understand more about the structure of model error we've got to go to Bristol.