Ecosystems: modelling the Earth

The acid test

Dr Neil Edwards:
Earth system models simulate the many interactions in real eco systems. They help us understand what processes are going on and how they affect each other. We can test models by asking them to make predictions that we can test against real data. The difference between what the model predicts and what the data shows is called model error. I'm in Bristol hoping that Jonty Rougier can tell me more about it. So Jonty, how can you actually measure model error in a climate model?

Dr Jonathan Rougier:
It's a difficult thing to measure. One source of error is simply that we don't actually know all of the physical processes that we would like to represent in our model. We just don't have that physical understanding. And another source of error, which is probably the dominant one for climate models, is that even though we do know the physics of the systems that we're modelling, we don't necessarily know the physics on the scale of the climate model. I think I experienced with climate models is they're quite good getting large scale features like temperature ride, but they're much worse at getting smaller scale features like precipitation correct.

Dr Neil Edwards:
So this is in a way a general problem that this problem of scale that you understand things on a small scale but you actually want to know about them on the big scale of climate model grid cells.

Dr Jonathan Rougier:
There are some processes where if you know them on the small scale they're relatively easy to scale up to the model scale. But there are others where, particularly a process where there's a million tarantulas, where scaling up is quite hard to work out, and difficult to get right.

Dr Neil Edwards:
So it sounds like there are two basic types of model error. There's an error related to the fact that we don't know the best values of these parameters in a model but there's still a whole another type of error related to the fact that the parameterisations weren't the right parameterisations in the first place, or the model isn't the right model in the first place, a kind of structural sort of error?

Dr Jonathan Rougier:
Right. So we could refer to those as parametric uncertainty and structural uncertainty. It's a very good way of breaking down the sort of uncertainty but we have to be a little bit careful because the two things are quite strongly related. You could imagine, for example, that if you had quite a naïve scheme for prioritisation that would lead to quite a large amount of structural uncertainty. Now say if you had a much more sophisticated scheme for prioritisation then you could reduce your structural uncertainty. So they're distinct, but they're also related. What we have here is North American temperature and North American precipitation and this dot here is our best understanding of the current value. We have the standard model and sixteen variants, so sixteen different choices for the priorities, and that gives us a cloud of model evaluations. This cloud is quite large, but also it does not contain the model value. The size of the cloud indicates the amount of parametric uncertainty. It's what happens when we choose different values for the parameters. You'll also see that the cloud itself is offset from the modern data point, the red dot, and that's really a representation of structural error. No matter how carefully we chose the parameters we still wouldn't expect any particular parameterisation to give us exactly modern American climate.

Dr Neil Edwards:
So we need computer models to tell us things that we couldn’t find out any other way, but to do that these models have to make approximations of the real world. These approximations, these parameterisations are the principle source of model error. Now error we can break up into two different types: parametric error where we don’t know the right values for model parameters; and structural error which represents the fact that the models are actually structurally flawed, they miss out certain processes. But we can improve our models by comparing them against reality, by comparing different versions of the models, and using statistics to tell us which models are best and which parameters are best.