Exploring mathematics: a powerful tool

Predicting climate change

Carmen Pryce:
A very much larger problem to explain is how the world's weather is governed by the ice caps at the Poles. In Antarctica, for instance, the seasonal break-up of ice is a natural phenomenon that takes place on a huge scale. Here's Colin Fox again.

Colin Fox, University of Auckland:
I have a map of Antarctica here. I can show you how the continent changes in size seasonally. Like most maps, this shows the land mass of Antarctica, the land that sticks up above the sea, so here's Antarctica, and South America, and New Zealand is down here. It also shows the extent to which the sea ice forms, the region where the sea freezes each winter, and it's this enormous area which is bounded by this line around here. And you can see that during winter while this region of sea has frozen over, it about doubles the area of Antarctica. In fact, this region of sea ice is about 20 million square kilometres. And then later in the Spring as the ice weakens, or more to the point, storms form that break up the sea ice through the ocean wave action, that ice breaks back towards the land and forms a region of broken ice that's known as the marginal ice zone. And the measurements that we make are just at the last part of that breaking process down here in McMurdo Sound, this little corner of the sea ice down here, where we can be safe while we're making our measurements. We measure the break-up process there, and ultimately try and extrapolate that to the break-up process all the way around Antarctica. And that expanding during winter and contracting again in spring, is the largest seasonal change that occurs on Earth, and it's almost certainly a driving force for the climate of the region and, in fact, it affects the climate and region such as New Zealand. I've got a picture here that will show you in fact the ice once it's broken, and this is the region of Antarctica, in fact, where we do our experimental work. So this is Ross Island here within McMurdo Sound, and you can see this region here of sea ice that has broken up because of the wave action. To give you an idea of scale, there's a flow here that's about the size of a football field, it's probably 25 or 50 metres this way, and 100 or so metres in this direction. And you can probably see that all of the flows have that same kind of scale. One of the questions that perplexed us originally was why is there this regularity when the conditions of ocean waves are very different from time to time that it breaks up? So this is a kind of thing that you might hope we can make a mathematical mode of because there seems to be lots of structure in the way the ice is breaking and so you might hope that working out a model on a relatively small scale would actually tell us important features about the way sea ice breaks all the way round Antarctica. The immediate question that I'd like to answer is really to build a mathematical model that predicts this regularity, that predicts this particular shape, all the details of how the ocean waves bend the ice – well we know that little bit already, I can already predict how the ocean waves will bend the ice - and roughly the qualitative features of how the breaking will occur. But there's much more beyond there – we'd like to understand the detail of this process.

Carmen Pryce:
Colin is just one member of an international project involving many researchers from several scientific disciplines including chemists, physicists and computer scientists, as well as mathematicians. In trying to model the way the ice cap changes with the seasons it's necessary to study the behaviour of the ice on a wide range of scales.

Colin Fox:
We have people who come with us who look at the detailed structure of the ice, perhaps on the scale of millimetres, trying to predict the mechanical properties of the next scale up, and then those people on the next scale pass on their results to me at the hundreds of metres

kind of scale, and ultimately I hope to pass on my results to people who work at the global scale predicting climate change in our region.

Carmen Pryce:
The very size and scale of the phenomenon that Colin and his colleagues are trying to understand is going to demand a very elaborate mathematical model. However, natural systems far smaller than the South Pole can still require complicated mathematical modelling.