Climate models benefit from medical methods

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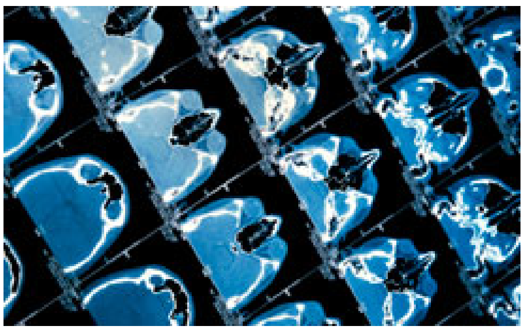

Researchers have used mathematical techniques taken from the analysis of medical images to bring climate models into closer agreement.

The breakthrough could let scientists make better predictions of the future climate under different scenarios for greenhouse-gas emissions.

At the moment, climate models often disagree even over very major features of the climate - for example, on the location and timing of monsoons. They find it particularly hard to represent rainfall and other precipitation accurately, both in their predictions for the future and in their simulations of historical climate.

So the search has been on for a way to bring the models' predictions closer to each other. But researchers at the University of Oxford realised that the software used to process medical scans was already doing something similar. Doctors often want to compare the scans of several patients' brains, for example, in search of common symptoms. To do this, they need to match up the various anatomical regions of the brain, which will be in different places in each patient.

'When you scan different brains, you need to compare them all to a common reference brain,' explains Adam Levy, an Oxford PhD student in atmospheric physics. 'Here we need to get the outputs of climate models to match observations better, but the principles are similar.'

Levy and colleagues adapted specialised software, called FNIRT, used in medical imaging to work out mathematical relationships between the same anatomical features in different patients, allowing each image to be stretched and squashed until the areas of interest are in the same place. This is known as 'warping' the images.

Levy likens it to starting out with photos of two people's faces and trying to make them look alike by stretching, squashing and deforming them. 'You might move one person's nose up, or stretch the other's eyes to make them wider,' he says. 'But you don't want to do anything too weird - you can't fold one of the pictures over or cut holes in it, because then you're losing part of the image. So it's about trying to bring the two images as close together while also making sure the mapping is sensible and doesn't change things too far.'

It turns out that trying to compare the output of different climate models isn't so very different. Each model has its own idiosyncrasies and tends to make distinctive mistakes. By analysing where in space and time each set of outputs tends to predict a major climate feature and then using warping techniques to transform them so that they agree better with historical observations, the team found they improve the accuracy as well as the consistency of each model's predictions. That is, they can get climate models to agree better on how monsoons and other features will be affected by climate change, giving us more confidence in the models' predictions.

The group tested the concept on an extreme scenario for future climate change, in which unabated CO_2 emissions have quadrupled atmospheric levels. They took 14 climate models and warped their historical simulations so that they agreed better with observations. They then applied these warps to their predictions in the hope that this would iron out disagreements between them. The result was a significant improvement in agreement between the models - around 15 per cent on average, though some areas benefited more than others. More than two thirds of the globe saw some increase in agreement.

'The long-term goal is to be able to make accurate predictions of average rainfall at a given time of year under a given CO_2 emissions scenario,' Levy says. 'But for the moment we've used an idealised example with very dramatic growth in CO_2 levels, to show that the techniques work.'

The team is now working on dedicated software to carry out warping on climate predictions, which are different from medical images in several important ways – for instance, they happen on the surface of a sphere. These peculiarities limit the effectiveness of simply adapting medical techniques to work on climate predictions; Levy thinks the new system, built from the ground up to work with climate models, could bring bigger increases in accuracy.

The technique could also help with detecting the effects climate change has already had on average rainfall rates, at the same time as demonstrating that these changes were due to human influence and not natural variability.

More information: Levy, A. et al., (2012) Can correcting feature

location in simulated mean climate improve agreement on projected changes?, *Geophys. Res. Lett.*, doi:10.1029/2012GL053964, in press.

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