The uncertainty principle

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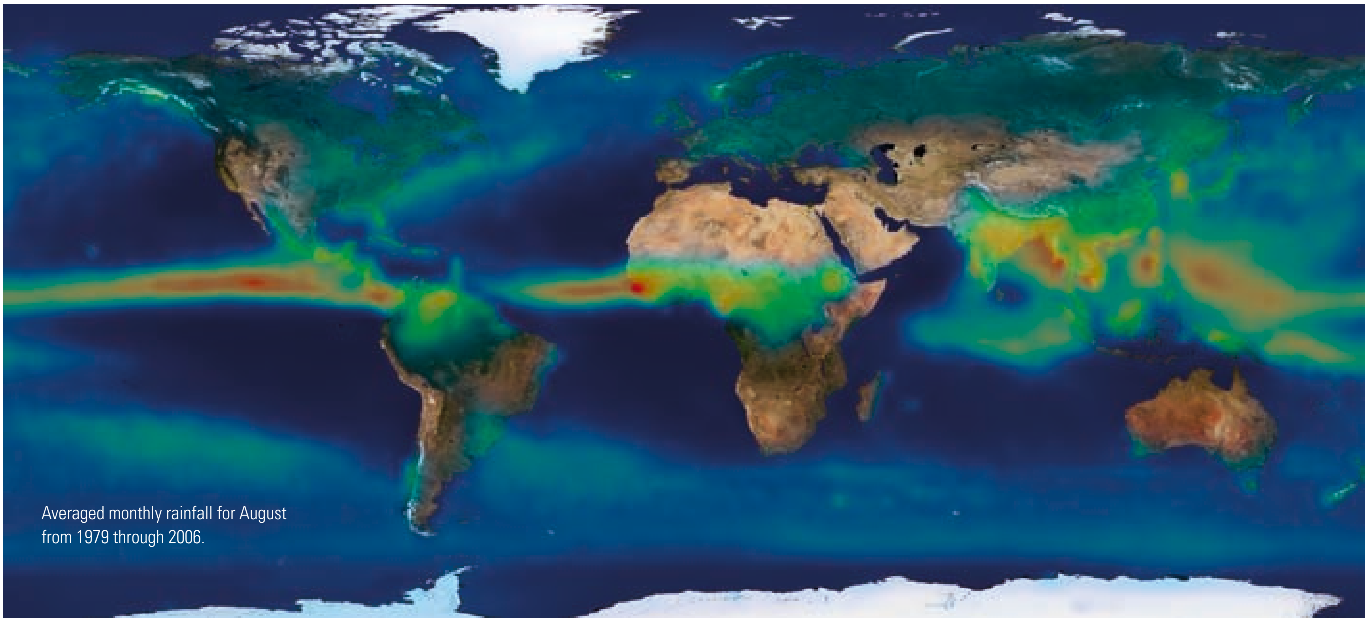

NASA/NOAA

Averaged monthly rainfall for August from 1979 through 2006.

FEW SCIENTIFIC issues raise as much debate as how environmental scientists should characterise and communicate uncertainty. NERC launched its 'Changing Water Cycle' research programme in February. At the launch, the issue of the degree of certainty about regional climate change arose, particularly regarding future rainfall in Britain: 14 climate models predict different results for southern Britain. If scientists were to use shorthand like 'We know little about the trend of rainfall likely in the southern parts of the UK over the next 50 years – not even the sign of the trend', in some quarters this could seriously diminish the credibility of all aspects of the science of global warming.

It remains difficult to explain convincingly why science can be less certain about the cause and future trends in some aspects of the Earth system yet at the same time be more certain about other aspects. Knowledge about the global-average near surface temperature and the role the changing carbon dioxide content of the atmosphere plays in causing temperature trends has been reasonably well established since Arrhenius's* classic work in 1888.

Climate is time-average weather. For some people the concept that one can understand and predict trends in climate whilst at the same time be unable to specify accurately the contributing weather events much beyond a couple of weeks into the future seems a step too far. A possibly helpful illustration from a different physical system is that we can very accurately specify the temperature of a volume of gas in a box whilst at the same time be unable to determine the motion of all the molecules that make up that gas – the basis of statistical mechanics.

Scientists want to both reduce and quantify the uncertainty, but in predicting future environmental change there tends to be a trade off between these two. One way that is likely to reduce uncertainty in climate predictions is to increase the number of mesh points (the resolution) that climate models use. This means more computer processing power is required. In addition, scientists need to run a large number of similar models to quantify the range of uncertainty. This ensemble of calculations is also very computer intensive. So then what is the right balance between putting (computer) resources into reducing and quantifying uncertainty?

Scientific uncertainty could be seen by policy-makers as a difficult thing to deal with ('the minister needs to know what the science says'), but perhaps its value is in opening up a range of options for action with various degrees of risk and consequences. If, as the Stern Review says, the economic cost of climate change is skewed to the low-probability high-impact events, then quantifying that, albeit low, probability becomes a central scientific issue. And then targeting adaptation to stave off the consequences of those events with a low return period is a cost-effective way to act. Also policy decisions nearly always have non-scientific factors, such as ethical and economic considerations and public support, that must be considered. So knowledge of the range of possible environmental futures can help, not hinder, in coming to an integrated view.

The scientific method assesses new ideas by testing how accurately the theories predict what happens in the real world. Part of this is to quantify the errors inherent in making the predictions and in measuring what is actually happening. These are the underpinning principles followed in the scientific understanding of environmental change, and so we are stuck with uncertainty and always will be!

** Swedish chemist Svante Arrhenius was the first to suggest rising levels of carbon dioxide would warm the planet. He estimated that doubling the level of carbon dioxide would raise global temperatures by 5ºC.*