

ANDY RIDGWELL

62 What will Earth's future climate look like?

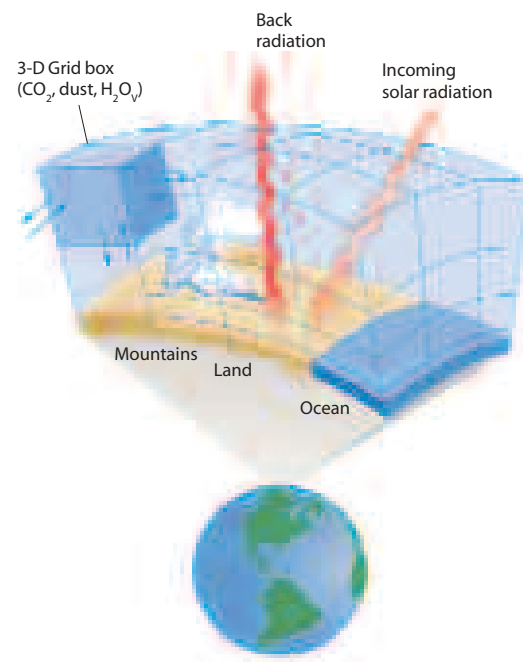
In tackling climate change, helping others is helping oneself.
PRESIDENT HU JINTAO, 2007

We have no spare copies of our planet on which we can experiment. This might sound obvious, but it highlights the problem of how we can determine what the future climate of Earth might look like in response to greenhouse gas emissions from the burning of fossil fuels and other human activities, other than by just waiting for it to happen. Clearly, it would be beneficial to know the answer well in advance, as this would give us the chance to avert the possibility of undesirable consequences. Here, we look into the computer modeller's crystal ball and consider some of the predicted effects of human activities on climate.

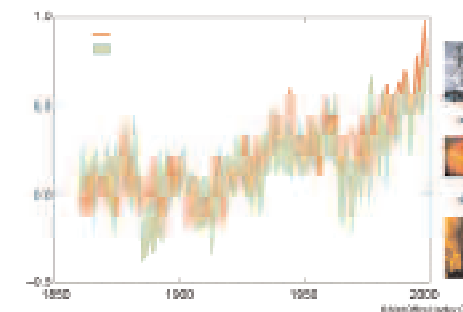
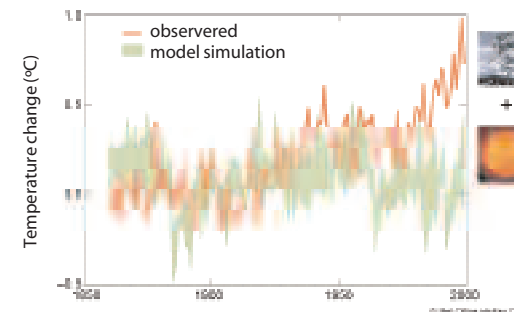
Modelling climates in computers

We are used to seeing forecasts on our TV screens predicting what the local weather might do in the next few days. These predictions are generated by first feeding into a computer details of how processes in the atmosphere such as cloud formation work, together with how the atmosphere reacts when it meets the underlying land and ocean surface. Rather than attempt to keep track of every single gas molecule and rain droplet in the atmosphere – an impossible task – the atmosphere is divided up into a 3-dimensional grid, often involving tens of thousands of different boxes. Each box keeps track of important properties within it, such as temperature, moisture content, and direction and speed of winds, and can interact with other boxes adjoining it. By making consecutive small steps forward in time (of 30 minutes, say), heat and moisture circulate through the atmosphere, storms move across the ocean and precipitation falls, perhaps as snow during the winter and rain during the summer.

In essence, the techniques required for predicting the climate of the Earth over the coming decades and centuries are much the same as this. Of course, a distinction must be made between 'weather' and 'climate' – climate being the weather averaged over time and space. So the uncertainties that begin to dominate in a weather forecast when it is extended beyond more than about a week do not mean that we cannot predict the Earth's climate more than seven days in advance. But how can we be certain that our state-of-the-art models of the Earth's future climate are credible and accurate?



Modelling climate – and climate change – using a 3-dimensional grid. caption to be written, caption to be written, caption to be written, caption to be written



Graphs showing how computer models compare with recorded temperature changes. When only natural causes are taken into account (left) the model lags behind, but when manmade factors are added (right) the two match well.

One important check is whether our models of the climate system can reproduce the historical changes in surface temperatures that we have actual records of. Impressively, although the various models made by research groups around the world use different techniques, for instance in the number of boxes, the methods of representing cloud formation processes, as well as in other details, all agree that the temperature signal resulting only from natural phenomena such as volcanic eruptions and El Niño events and the variability in the energy supplied by the Sun, either in isolation or together, are a very poor fit for the records made by instrumental observations. It is only when the warming influence of the known increase in greenhouse gas concentrations in the atmosphere (and some cooling due to the industrial emissions high into the atmosphere of reflective sulphate aerosols) are taken into account that the instrumental record is reasonably reproduced.

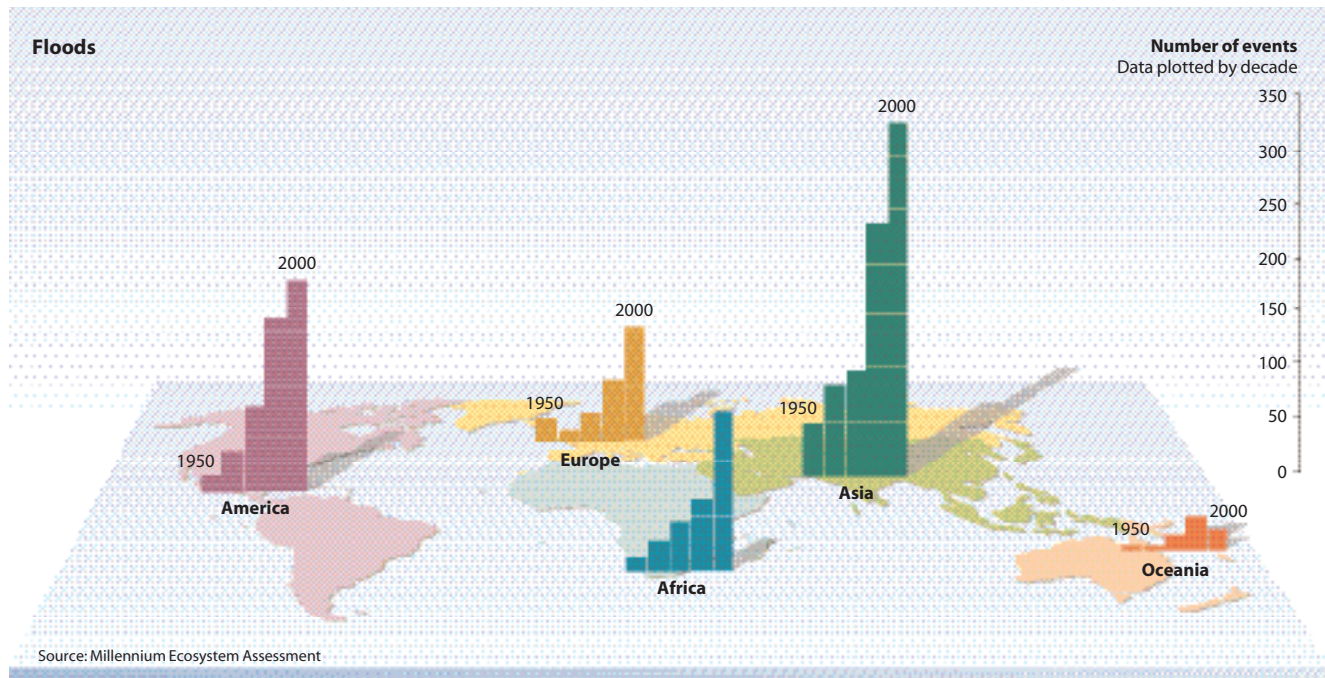
Such is the economic and political importance attached to getting the predictions right that the United Nations established the Intergovernmental Panel on Climate Change (IPCC). This brings together the world's leading experts on climate change to scrutinize and evaluate the available observations and models. In 2007 it was awarded the Nobel Peace Prize jointly with Al Gore.



Extreme weather on the increase? (Clockwise from top left) Hurricane Linda off the west coast of North America; flooding in the aftermath of Hurricane Wilma in Florida, 2005; drought in Botswana; a tornado in South Dakota.

Where are we going?

The most recent assessment by the IPCC of projected changes in climate is of globally averaged surface air temperatures increasing by anywhere from about 1°C (about twice the observed warming since the industrial revolution) to over 6°C; most of the uncertainty is the result of not knowing how much CO₂ and other greenhouse gases we are likely to release into the atmosphere



Above Increased flood events plotted by decade, 1950s-2000. caption to be written, caption to be written, caption to be written, caption to be written

Opposite Polar bears search for food at the edge of the pack ice in Churchill, Canada. In some climate projections (IPCC), Arctic late-summer sea ice will disappear almost entirely by the latter part of the 21st century.

in the future. But thinking only in terms of a simple global average temperature when the climatic conditions on our planet vary so much from place to place is not very helpful. We therefore need to look in more detail at regional and seasonal patterns, which are of greater meaning to our personal experiences.

For instance, it is considered very likely that heat waves will become more frequent. And it is hardly very surprising that snow cover is projected to contract in response to the higher temperatures, but this has important implications for adequate summer fresh water supply (from melting of the winter snow-pack) in regions such as western Canada and the Himalayas. Sea-ice is projected to shrink, with polar bears progressively losing their hunting habitat – just one of many changes to Arctic ecosystems. Another consequence of warmer surface temperatures is the release of more energy into the atmosphere, with the result that typhoons and hurricanes will probably become both more frequent and more intense in the future, with obvious economic impacts.

Another important future change concerns rainfall. The higher the temperature of the ocean, the more evaporation there will be. And more

moisture in the atmosphere of course means more rainfall in total. However, the detailed picture is not so simple, and some places on Earth are expected to get drier not wetter. For instance, high latitudes are likely to receive increases in the amount of precipitation, especially in the winter. One result of this could be an increased frequency and severity of flooding in already susceptible areas. But many of the already arid and semi-arid regions on Earth could see a decrease in rainfall, implying an increased frequency and severity of drought. There is nothing particularly 'fair' about the reaction of the climate system in response to our interfering with it.

The greatest uncertainty of all is the unpredictability of we humans in our personal and collective political and economic decisions. Because the degree of climate change increases with the higher concentrations of CO₂ in the atmosphere (p. 000), the more fossil fuels we burn and the faster we burn them the more CO₂ will build up in the atmosphere. We may perhaps determine to reduce our fossil fuel use, or, conversely, we may continue our love affair with large cars. Whether we will simply run out of oil is another question we ask shortly (p. 000).

