The use of models to predict climate: Climate*prediction*.net results so far

You have seen how difficult it is to predict the weather. This activity looks at how scientists are developing ways of predicting long-term climate using **models**.

1. What do you understand by the word model?

2. Which of the following do you think might affect the average global temperature?

distance of Earth from Sun
dust in the atmosphere
concentration of carbon dioxide
Sun's output
wind strength
cloud cover
ice cover
area covered by trees
concentration of water vapour in the atmosphere
ocean currents
ozone concentration
volcanic eruptions
temperature of the Earth's core
concentration of oxygen

3. For the factors in bold type suggest whether an increase would result in warming or cooling.

4. Climate change is often discussed in terms of average global temperature. How many temperature measurements would you need to take to know the average global temperature? Where would these measurements have to be taken?

5. How accurately do you think we can know the average global temperature?

Developing models to predict future climate
The factors identified in question 2 as well as others can affect the climate. To combine them to make a prediction you have to use a mathematical model. You may have used the simple climate model which allowed us to calculate the way in which a change in the energy received from the Sun affects the Earth's temperature. This model used equations to relate the final temperature of the Earth to this one variable. In the real world there are many, many more variables to be included in a model. These variables interact with each other too so that the situation at each point on the Earth's surface has to be calculated using hundreds of thousands of equations. Some of these interactions are not well understood.

The climate*prediction*.net experiment is a research project which is trying to use a state-of-the-art model of the atmosphere and oceans to predict accurately what our future

climate might be. It does this by seeing what hundreds of thousands of climate models predict. Each model downloaded from climate*prediction*.net is unique but equally realistic. The models differ in their *starting conditions* (what the atmosphere looks like now) and their *parameters* (constants which are poorly understood but which are fundamental to the model, for example the relationship between the size of the droplets in a cloud and how much it rains). Some combinations of parameters may produce a very realistic atmosphere, some may not.

Climate model data

The data that you will be investigating is the output of the climate*prediction*.net model. It is not data that is based on the observed weather in any way, but is data that was generated by a computer, solving hundreds of thousands of equations for each point on the Earth's surface. Figure 1 shows the results of a set of 27 000 different combinations of conditions.

Phase 2 (given the dates 1825-1840) is a hindcast (literally a forecast done as if it were 1825 and we had no knowledge about the future) of typical pre-industrial conditions (so Greenhouse Gases etc. are as if there were no industrial activity on the Earth). Incoming solar energy, volcanic activity and other greenhouse gases are also held constant.

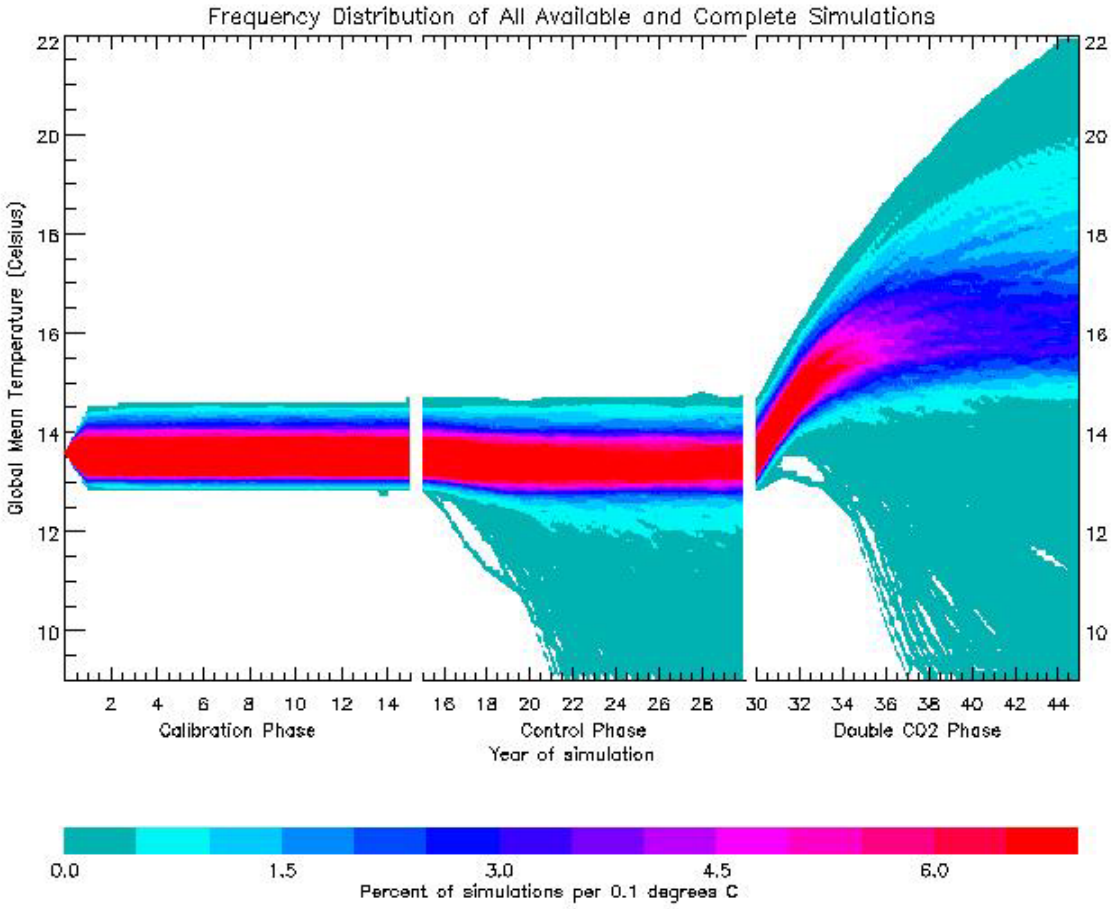

Figure 1: The first 27,000 model run results

6. Do all the answers in Phase 2, 1825 – 1850, look equally realistic for the period before carbon dioxide increased? How do we know that some of them must be wrong?

7. What does this mean about the combination of parameters that were put into these particular models? We say that these wrong models are *unstable*.

Once we have identified the large number of different models that seem realistic in phase 2 we can use them to see the effect of increasing of carbon dioxide in phase 3.

What is phase 3? Phase 3 (given the dates 2050-2065) is a forecast based on a doubling of carbon dioxide levels in the atmosphere. This is set to happen in about 2050.
At the beginning of phase 3, CO_2 values are doubled to 564ppm. They are then held constant throughout the phase. Everything else (solar energy, volcanic, other greenhouse gases…) is held constant.
The difference between the equilibrium temperature in phase 2 and the equilibrium temperature in phase 3 is known as the *climate sensitivity*. This is a common and simple measure of how a climate model reacts to changing CO_2 values.
Figure 2 shows the results again with all the unstable models removed.

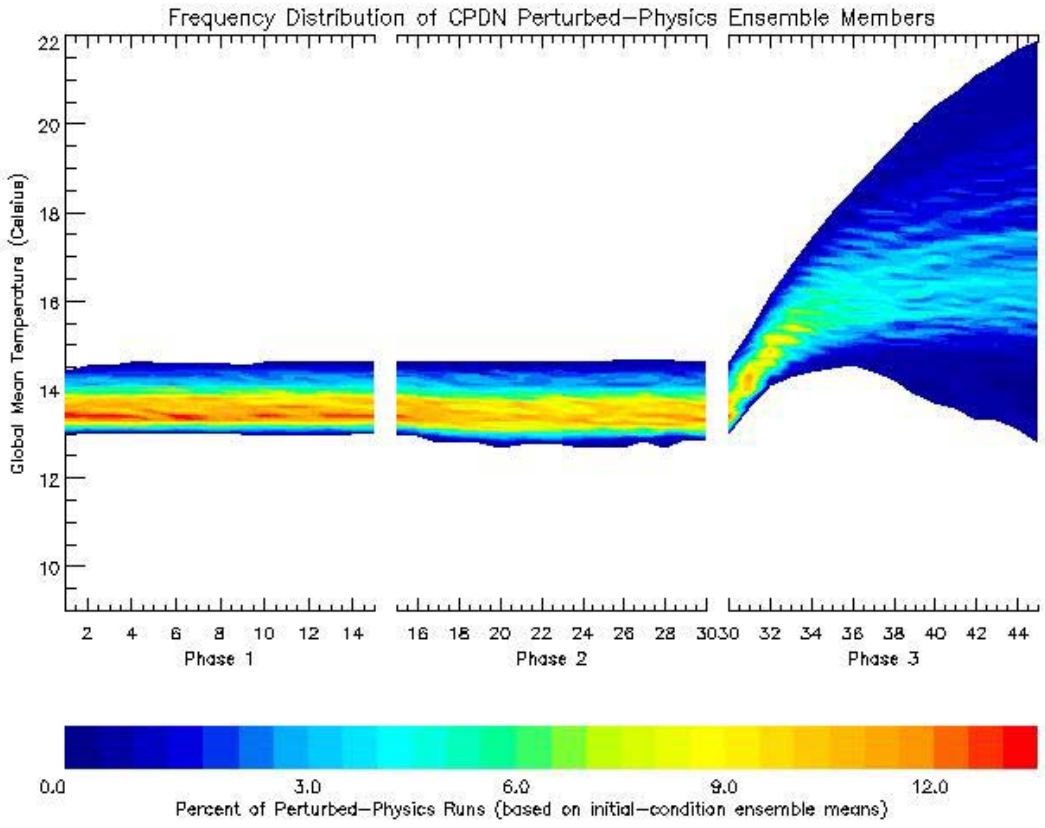

Figure 2: all stable models

8. What do the results so far show happens at the beginning of phase 3?

9. By the end of phase 3, what is the spread in global mean temperatures?

10. What can *definitely* be said from Figure 2 about global mean temperature when CO_2 is doubled?

11. What can be said from Figure 2 is *most likely* about global mean temperature when CO_2 is doubled, assuming the results so far are representative of the final results?

12. In what ways is phase 3 like, or unlike, the real world?

13. If a headline based on Figure 2 said

"Scientists say temperature set to warm by 8°C"

explain as you would to a friend why this headline somewhat misrepresents what the climate*prediction*.net results show.

How could this information be used?
Climate sensitivity is not a very useful quantity in itself for policy makers. However, if the climate scientists now concentrate on those models which are particularly sensitive, or insensitive, to climate change, and rerun them with more realistic scenarios of changing greenhouse gases, volcanic activity etc., it will become possible to see what extreme climates might happen – and this information is vital.

More about climate*prediction*.net
This research project is a joint research project funded by the Natural Environment Research Council (NERC) and the Department of Trade and Industry. Its aim is to use the large number of idle computers worldwide and the power of the internet to predict and understand the climate. If you visit the website at www.climateprediction.net, you can join 100,000 people around the world taking part in this project by downloading a unique simulation model of the Earth's climate onto your home computer. The downloaded program runs as a background process (it does not affect normal computing). The graphics packages supplied with the model show how weather patterns develop.

For a more thorough investigation of model results go to
http://www.climateprediction.net/schools/docs/myresults.doc

Results from these experiments will contribute to the 4th Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) and will help policy makers plan for the effects of climate change.