

Dynamic modelling

Introduction

This is the first of two activities introducing dynamic modelling. It introduces key concepts and allows students to interpret the results of some modelling, and to learn more about the use of computer models and their limitations.

The activities

Introduce the activities by discussing why we need to predict the future; the main reasons are because we need to plan resources, but also because in some cases we can introduce policies to influence the changes. The Kyoto agreement, and subsequent negotiations, are examples of this.

Activity 1, students can work in pairs or singly to study the diagrams and answer the questions. Discuss the answers to the questions and the explanation of a computer model in the whole class.

Note Activities 2-6 are in Dynamic Modelling - 2

Answers to questions

Activity 1

- 1 Population size (indicated by line) continues rising throughout the period.
- 2 The rate of growth (indicated by bars) increases rapidly from around 1950 and slows down after 2000.
- 3 Yes the match is good, with small fluctuating differences.
- 4 Both show a sharp rise in sea level. The quadrupling of carbon dioxide is predicted to give 1.8 m, almost double the rise, 1.0m produced by a doubling.
- 5 Doubling is predicted to have a major effect for the next 400 years but after that circulation will return to a pattern similar to today. A four-fold increase is predicted to change ocean circulation permanently by 2100 with the maximum effect reached in about 250 years. Britain is warmed by the Gulf Stream. If ocean currents change, then the Gulf Stream might be diverted and Britain could suffer an ice age.

NOTE: Every effort has been made to obtain permission to use the graphs in this activity.

December 2010

How Science Works

Da A dynamic model is a set of proposed inter-relationships between key variables in a situation. Dynamic models can be constructed and implemented on a computer. They are widely used in science to make predictions and to test explanations in complex situations.

Db A dynamic model incorporates hypotheses about the important variables in a situation, and the way they inter-relate. The outputs from the model will depend on the assumptions built into it and the data used to set the initial conditions. Data derived from a computer model are therefore less trustworthy than data that have been measured directly.

Dynamic modelling

Predicting futures

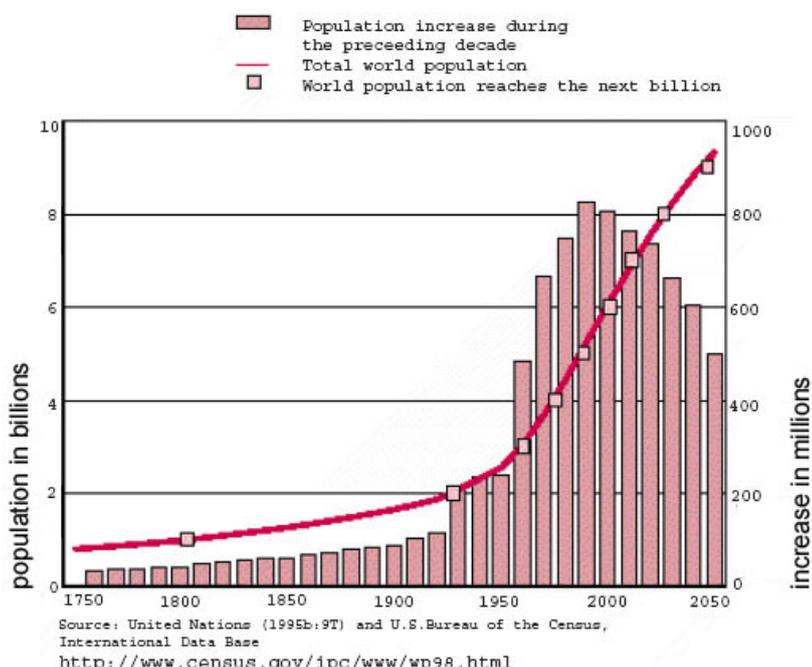
Predicting the future helps us in planning what to do in the present. To help us in making predictions, computer models are now widely used. Some predictions are easy to make, because the behaviour of the system is well understood. A simple pendulum, or a ball rolling down a slope are examples. They can be easily and precisely modelled in a computer simulation, and the output from the model can be found to correspond to what actually happens.

But to inform policy and decision-making, we usually want answers to questions that are more difficult: 'what will the world population be in 2050?' or 'what will be the effect on global warming of a doubling in carbon dioxide levels?' In constructing computer models of complex systems, simplifications need to be made; it is not possible or desirable to represent every detail of the system being modelled. Choosing what to represent, and what to leave out, requires judgment, and therefore it is legitimate to challenge the assumptions made in the construction of any model.

In this set of activities, you will look at some examples of how models are being used to make predictions about important global changes, such as population size and climate. **Activity 1 Some models of global change.**

There are many practical reasons for knowing how the population is going to change. Schools and hospitals need to be built, and teachers and doctors need to be trained; it is helpful to know how many children and how many old people there are likely to be in the future population. Figure 1 overleaf shows one prediction of world population trends between now and 2050. These figures have been calculated from a knowledge of the existing populations of each of the countries in the world, and by making assumptions about the trends in the birth rates and death rates in these countries.

Figure 1 Predicted world population



We all have a basic understanding of the mechanisms of population change – births add to the population and deaths decrease it. The next model deals with a phenomenon whose mechanisms are less familiar – global climate change.

Figures 2- 4 show the results from a computer model that simulates the effects on climate of increases in atmospheric carbon dioxide. Two different scenarios are used, one with a doubling and one with a four-fold increase in carbon dioxide concentrations.

Figure 2 Predicting change in global temperature

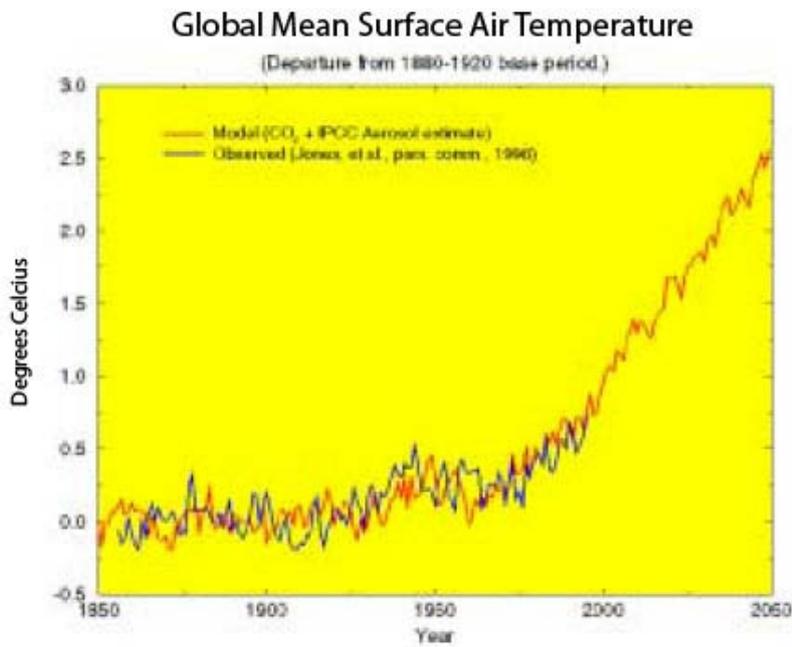
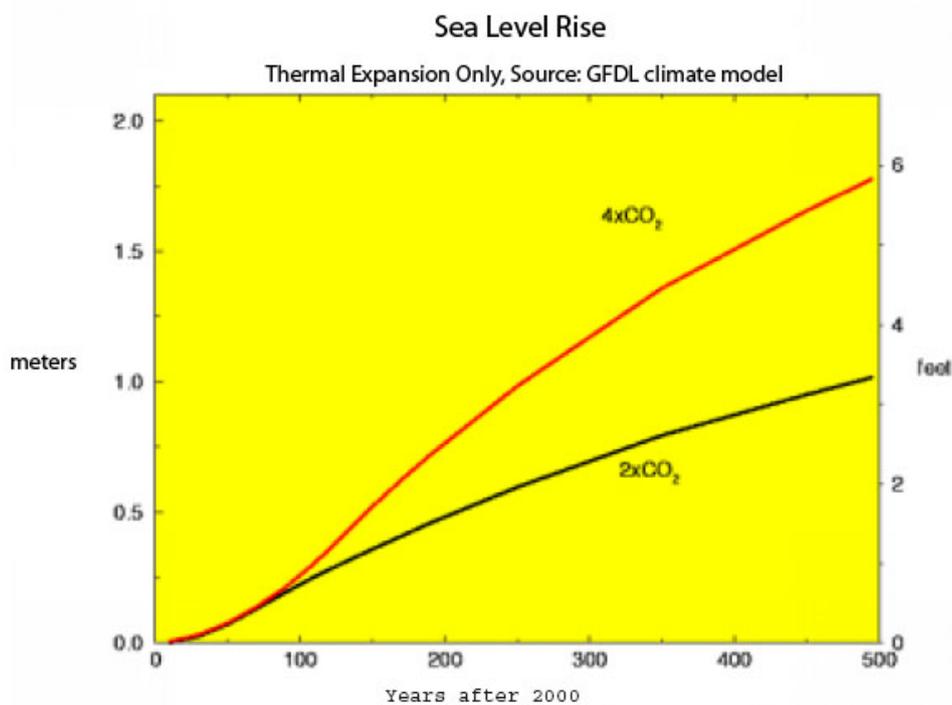
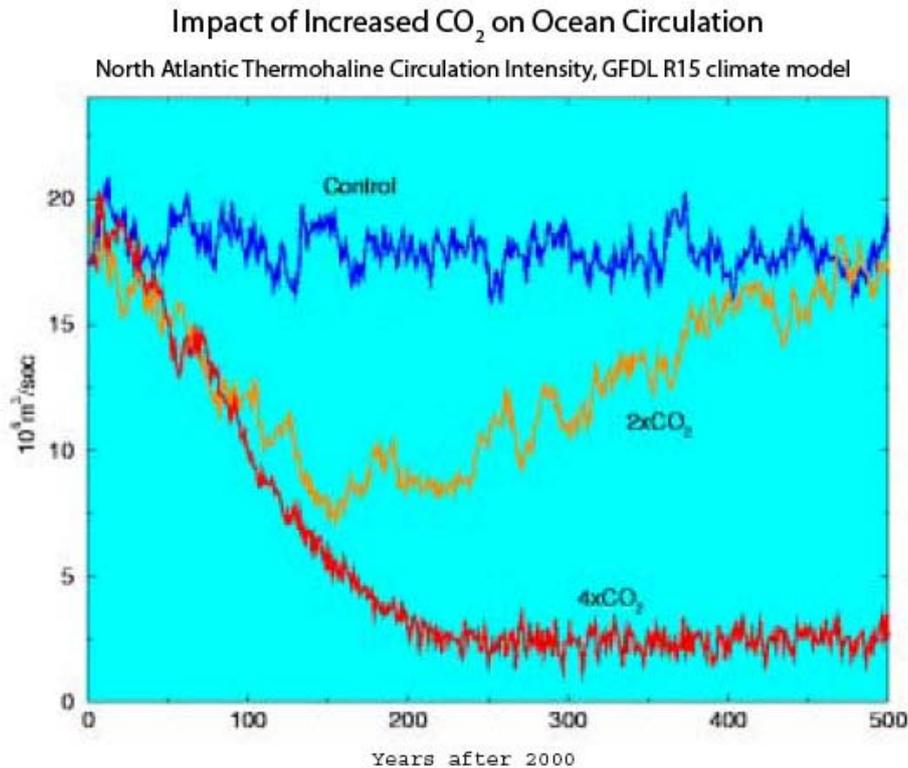


Figure 3 Predicted change in sea level



http://www.gfdl.gov/~tk/climate_dynamics/climate_impact_webpage.html#section2

Figure 4 Predicting change in ocean circulation



Questions

- 1 How would you describe what happens to the world population up to 2050 as predicted in Figure 1?
- 2 How would you describe what happens to the rate of population increase up to 2050 as predicted in Figure 1?
- 3 Figure 2 shows how the climate change model has been applied to the past as well as the future. Actual and predicted changes in global temperature plotted to test the validity of model. Are they close?
- 4 Figure 3 shows the effect on sea level of thermal expansion due to a doubling and quadrupling of carbon dioxide. Describe what is predicted to happen over the next 500 years.
- 5 Figure 4 shows the effect on ocean circulation of no change, doubling and quadrupling of carbon dioxide. Describe what is predicted to happen over the next 500 years. How would this affect Britain?