



Royal Meteorological Society

## Java Climate Model Worksheet

The aims of this practical are to

- allow you to see some of the predictions for greenhouse gas emissions, and how they translate into greenhouse gas concentrations in the atmosphere
- see how greenhouse gas concentrations relate to temperature in a very simple model.

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You will investigate the data produced by a climate model which is a numerical representation of how the atmosphere behaves.

The model is very simple. It does not even try to represent many of the processes operating in the atmosphere, and greatly simplifies some others. This means that it is both easier to see how a change in one factor impacts another.

It is an 'Energy Balance Model'; a zero or one dimensional model which predicts sea-surface temperatures based on the energy balance of the Earth. Because it does not attempt to calculate the complete dynamical structure of the atmosphere, by solving the appropriate equations of motion, it can produce results almost instantaneously.

Full GCMs (General Circulation Models/ Global Climate Models), which try to represent all the significant processes operating in the atmosphere, would take weeks of computer time to produce the equivalent results.

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Navigate to <http://chooseclimate.org/jcm/jcm4/> and select JCM4.

This is a simple climate model which works by balancing the flow of energy in the Earth's atmosphere, but also includes a simple representation of the carbon cycle and some of the chemistry going on in the atmosphere. You will see lot of graphs and menus. Follow the instructions below to complete the exercise. If you go wrong at any point or get lost just click on the 'reset' button, on the right above the graphs, and you can start again.

- 1) Select the '**Complexity**' menu and click on '**simplest**'
- 2) Select the '**Layout**' menu and click on '**1 plot**'
- 3) The single graph which appears on your screen shows CO<sub>2</sub> emissions (y vertical axis) against time (x horizontal axis). This is one particular scenario of how CO<sub>2</sub>emissions may change with time in the future.

4) By moving the cursor along the curve you can read the CO<sub>2</sub> emissions level (y= ). Move to the peak of the curve, you can see that CO<sub>2</sub> emissions peak in 2019, with a value of 7339.

5) Select the '**Layout**' menu and click on '**2 row**'.

6) A new graph, showing CO<sub>2</sub> concentrations, should have appeared on the bottom of your screen. This is the concentration of CO<sub>2</sub> in the atmosphere that is expected to result from the emission scenario in the top graph. The values shown on the bottom graph are in themselves values that have been predicted by a model, one which took into account how we think an increase in CO<sub>2</sub> concentration will affect the rate at which CO<sub>2</sub> is removed from the atmosphere by green plants, plankton etc.

7) With this scenario of CO<sub>2</sub> emissions, how is the concentration of CO<sub>2</sub> in the atmosphere expected to change?

It is expected to stabilise at 500ppm, just over twice the pre-industrial value.

This is therefore a scenario in which 'stabilisation' has been achieved.

8) By moving the large black cross around, you can affect what stabilisation level is reached, and when. If the line goes off the top of the axis, you can extend the axis by clicking on the top number on the axis and dragging it down. The emissions plot in the top panel will adjust to your new stabilisation scenario, to show how global emissions would have to change to achieve that stabilisation.

Note that emissions do not have to be zero for concentrations to stabilise – as long as CO<sub>2</sub> is removed from the atmosphere at the same rate as it emitted, concentrations can stabilise.

9) What about other scenarios for CO<sub>2</sub> emissions/ concentrations?

Select the 'mitigation' menu. The lower 5 items allow you to choose different mitigation strategies which might be adopted globally to limit CO<sub>2</sub> emissions. Select each in turn and see what happens.

10) The Intergovernmental Panel on Climate Change considered scenarios in which there was no global policy on greenhouse gas emissions, but where different rates and types of global development determined how CO<sub>2</sub> emissions developed.

To see these scenarios, first select the '**mitigation**' menu and choose the first option '**SRES no climate policy scenarios**'. Next select the '**SRES**' menu and choose from the scenarios offered.

### **What are the SRES scenarios?**

The **A1** storyline and scenario family describes a future world of very rapid economic growth, global population that peaks in mid-century and declines thereafter, and the rapid introduction of new and more efficient technologies. Major underlying themes are convergence among regions, capacity-building, and increased cultural and social interactions, with a substantial reduction in regional differences in per capita income. The A1 scenario family develops into three groups that describe alternative directions of technological change in the energy system.

The three A1 groups are distinguished by their technological emphasis:

- fossil intensive (**A1F1**),
- non-fossil energy sources (**A1T**)
- a balance across all sources (**A1B**)

(Note: A1B where balanced is defined as not relying too heavily on one particular energy course, on the assumption that similar improvement rates apply to all energy supply and end use technologies.)

The **A2** storyline and scenario family describes a very heterogeneous world. The underlying theme is self-reliance and preservation of local identities. Fertility patterns across regions converge very slowly, which results in continuously increasing population. Economic development is primarily regionally oriented and per capita economic growth and technological change more fragmented and slower than other storylines.

The **B1** storyline and scenario family describes a convergent world with the same global population that peaks in mid-century and declines thereafter, as in the A1 storyline, but with rapid change in economic structures toward a service and information economy, with reductions in material intensity and the introduction of clean and resource-efficient technologies. The emphasis is on global solutions to economic, social and environmental sustainability, including improved equity, but without additional climate initiatives.

The **B2** storyline and scenario family describes a world in which the emphasis is on local solutions to economic, social and environmental sustainability. It is a world with continuously increasing global population, at a rate lower than A2, intermediate levels of economic development and less rapid and more diverse technological changes than in the B1 and A1 storylines. While the scenario is also oriented towards environmental protection and social equity, it focuses on local and regional levels.

The **IS92a** scenario came out of the previous IPCC report.

11) What temperature change does this model predict for each of these CO<sub>2</sub> emissions scenarios?

Select the '**plot**' button on the top right of the CO<sub>2</sub> emissions graph and select '**temperature**'.

Note that this model is very simple – temperature adapts to CO<sub>2</sub> immediately. In the real world, it can take a while to adjust (10s of years).

12) Now look through all the different CO<sub>2</sub> emissions scenarios again and see how the future global temperatures react in this model.

13) Do investigate the model in more detail, but bear in mind that it is a simple model, and some things (such as regional changes in temperature) are not very trustworthy.

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