CSIRO MK3L lab projects

The following projects are designed to test your understanding of some of the concepts that you will learn throughout the Winter School but also to get you thinking more broadly about the implications of modifying the climate system. Projects will be allocated during the first day of the winter school. Each project requires you to design an experiment that you can then run using the CSIRO MK3L Global Climate Model (see Phipps et al. 2011). In addition to providing a user manual, in the first lab we will go through what this model entails and how you can set up and run an experiment. Everyone will be provided with a 'control experiment' against which you can compare with your chosen experiment.

Project questions are deliberately broad so there are several approaches you could take, all of which might be valid. We can provide hints for what you could do and some references to get you started.

Projects to small groups (3-4 people) and there will be up to 3 groups working on each project.

References

Phipps, S.J., Rotstayn, L.D., Gordon, H.B., Roberts, J.L., Hirst, A.C., Budd, W.F. 2011. The CSIRO Mk3L climate system model version 1.0 - Part 1: Description and evaluation. *Geoscientific Model Development*, 4 (2), pp. 483-509.

CSIRO MK3L technical manual.

Project 1: How would a poleward shift of the storm tracks affect meridional overturning?

Storm tracks (the relatively narrow zones over oceans where storms travel driven by the prevailing winds) have been shown to shift polewards in the Northern and Southern Hemisphere due to increases in anthropogenic greenhouse gases (e.g. Jin 2005; Wu et al. 2010). This project is designed to test what some of the potential follow on effects of such a shift could have on other aspects of climate and ocean circulation.

It is likely you will need to design an experiment where you increase global CO_2 emissions. You should run the experiment for 50 years.

Project 2: Could sudden improvements in carbon capture and storage technologies help reset the Earth's climate?

Some studies suggest that using negative emission strategies are necessary in order to mitigate climate change. Current technologies do not allow for large-scale carbon capture and storage, however what would happen if in 25 years, technologies were developed that would permit instant CO_2 capture from the atmosphere and return to the pre-industrial levels? Could the planet return to its original state? If so, how long would it take; if not, how much did it recover?

In order to do this, you will have to change the CO_2 concentration from the input file and launch the model for a certain amount of time. Then change the CO_2 input file again to its pre-industrial concentration (as in the control run) and keep running the model.

Project 3: Why was the Sahara 'green' during the mid-Holocene?

Studies have shown that during the mid-Holocene (~6000 years ago) North Africa was significantly wetter than it is today (the so-called 'Green Sahara'). This has been linked to changes in the Intertropical Convergence Zone (ITCZ). CO_2 levels were also lower than present. Is it possible to recreate these wetter Sahara conditions in the model and link to the ITCZ and/or can you find other large-scale teleconnections to the region that differentiate the mid-Holocene from the present-day climate?

For this you will need to change the epoch in the model experimental setup and set CO_2 concentrations to appropriate values.

Project 4: What are the different changes in north-south transport in the ocean and atmosphere if Greenland melted versus Antarctica?

Antarctica and Greenland have the two biggest ice sheets on the planet. However, due to different ocean and atmospheric dynamics, their rate of melting and the subsequent impacts differ. To assess how the effect on the climate of each of these ice sheets melting is different, you will need to change the freshwater hosing mask in the input files around Greenland and Antarctica. This mask tells the model to add freshwater at certain locations.

You should run the experiment for 50 years.

Project 6: What is the impact on regional climate if the Amazon was completely forested versus completely deforested and in worlds with and without global warming?

Land use and land cover change can have a substantial impact on the climate especially at a regional level but there is some debate about the magnitude of change compared to the impact from rising CO_2. In this project the idea is to investigate how large the impact of the land is on regional climate and contrast that with the magnitude of the effect from increasing CO_2.

For this project you will need to change the vegetation categories in the vegetation mask and set different CO_2 levels in the input file.

You should run the experiment for 50 years.

Project 5: Could the climate effects of increasing CO_2 emissions be offset by the Earth's surface reflecting more sunlight?

Geoengineering (or climate engineering) is a way of trying to mitigate the adverse effects of global warming through deliberate large-scale intervention in the Earth's climate system. This project aims to look at one aspect of geoengineering known as solar radiation management. This attempts to offset the effects of greenhouse gases by causing the Earth to absorb less solar radiation.

For this you will need to run two experiments: one where you just increase CO_2 emissions and another where you increase CO_2 emissions while increasing the Earth's albedo (its ability to reflect sunlight).

You should run the experiments for 50 years.