Information on obtaining and using GENIE

Information and documentation about the GENIE earth simulator can be found on the project wiki site:

https://source.ggy.bris.ac.uk/wiki/GENIE

For further information and the relevant password to obtain the code please contact the GENIE project team:

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After you have obtained a username and password follow the weblink below to download the code.
https://source.ggy.bris.ac.uk/wiki/GENIE_GENIELab#Downloads

System requirements and additional prerequisites

Note that in addition to the source code, GENIE makes use of several applications and packages. You must have the following list of prerequisites installed on your computer, before you can run GENIE:

- Python.
- Perl (for the automatically generated documentation).
- GNU make.
- The BASH shell.
- The NetCDF libraries. See the using netCDF page for more information about downloading and installing netCDF.
- A C++ compiler, such as that from the GNU Compiler Collection (GCC).
- A Fortran compiler (including support for Fortran90). Compilers which are known to work with GENIE include: Intel, PGI, Pathscale, Sun, GNU gfortran, g95

GENIE can also be built for Windows platforms with a suitable build environment.

Follow link below for information on creating a build environment in Windows.
https://source.ggy.bris.ac.uk/wiki/GENIE_WindowsCompilation#Prerequisites

Modelling Practical (non-assessed) – Introduction to GENIE & CO2 experiments

You will be carrying out experiments with the GENIE earth system model of intermediate complexity (EMIC). Once you are basically familiar with the model, you will carry out CO2-**forced** experiments that are designed to investigate:

- Anthropogenic Forcing of Climate, 1800-2100
- Equilibrium Climate Sensitivity

The forcing is prescribed as CO_2 emissions. The purpose of this practical is to give you some direct experience of an EMIC: how fast (slow!) it runs; the kind of experiments that we carry out with such models; the kind of data produced. The practical takes 2.5 hours, following a short talk and demo, split into stages. A time is estimated for each stage. Don't worry if you are unable to entirely complete the practical by 5 pm, as the model may run slowly (e.g., 100 years in ~10 minutes), but aim to start each stage close to the time suggested. While the model is running (slowly), look at data from previous runs. Be patient throughout – you're running an Earth System Model with a dynamical 3-D ocean and a closed carbon cycle!

1. Getting Started

See notes on first page about obtaining the "GENIE Earth system simulator"

Once you have sucessfully installed and opened GENIE
You will see several features:
- a map of the world on the right
- buttons that provide options to view different model fields on the map (below map)
- buttons to set up experiments (top right)
- buttons to control runs (start, stop, reset)
- buttons to look at model data ("Northern hemisphere air temperature", etc.)

Please make sure you copy any data you require from this folder to
"my documents" or a memory stick before logoff from the computer.

There is an extensive User Guide on GENIE under "Show guidelines".

2. Initial State (2.40-2.50)

The results that appear by default – the initial state – are obtained from a long spin-up experiment. The model Earth System is very near to equilibrium – i.e., rates of change with time are very small. Before you carry out any experiments, have a good look at the many different model fields. In particular, focus on physical climate variables:
- Ocean temperature, salinity and currents (at each of 8 levels in the ocean)
- Air Temperature and Specific Humidity
- Precipitation and Evaporation
- Atmospheric Winds
- Sea Ice concentration and thickness

Consider some basic features:
- Land-Ocean contrasts
- Longitudinal contrasts in ocean variables
- Variation with depth in the Ocean

Also look at the ocean topography to get an impression of model resolution.

3. Idealized CO_2 forcing (2.50-3.00)

Run short (50-year) experiments to see what happens when CO_2 is emitted to the atmosphere. Do this by typing in year and emission rate data (GTonne C per year) under "Adjust emissions". Try a range of emission scenarios:

- a symmetric peak (e.g., specify a large value in year 10 and zero in year 20)
- a continuous non-zero value (e.g., the same non-zero in year 0 and year 50)
- a linear increase from zero (e.g., a large value in year 50)

Observe what happens to the anomaly of the variable you have chosen to plot* (e.g., air temperature). Observe the lengthening time series of annually averaged anomalies in selected variables (tick "Show Change"). Note differences between the three experiments suggested above.

When the experiments are complete (if time permits): Look in the results folder at the time series of atmospheric CO_2 concentration (Atmospheric pCO2). What happened?

* N.B. DO NOT CHANGE SELECTED MAP VARIABLE DURING A RUN

4. Anthropogenic CO_2 forcing (3.00-3.30)

Now run 300-year experiments that mimic the greenhouse gas emissions associated with the industrial revolution and subsequent global development, spanning 1800-2000, and an IPCC scenario for 2010-2100. The total global emissions data in selected years, should again be typed in under "Adjust emissions" as tabulated overleaf (***bold italic***):

Actual Year	GENIE Year	Global Emissions* (GTonnes C per yr)
1800	*0*	*0.008*
1825	*5*	*0.017*
1850	*30*	*0.054*
1875	*55*	*0.188*
1900	*80*	*0.534*
1925	*95*	*0.975*
1950	*120*	*1.630*
1975	*145*	*4.615*
2000	*200*	*6.745*
2010	*210*	*8.65*
2020	*220*	*11.19*
2030	*230*	*14.61*
2040	*240*	*18.66*
2050	*250*	*23.10*
2060	*260*	*25.14*
2070	*270*	*27.12*
2080	*280*	*29.04*
2090	*290*	*29.64*
2100	*300*	*30.32*

* IPCC SRES A1FI Emissions Scenario after 2000 (CO2 emissions only)

For more the complete dataset from which the historical estimates are taken, see
http://cdiac.ornl.gov/trends/emis/glo.html

Observe selected time series (e.g., Atmospheric pCO2) and evolving anomaly maps (e.g., air temperature). [In the first decade or so, you will notice slight reduction of CO2 and associated cooling – this is a very minor transient re-adjustment of the model after continuation from the end of a spin-up that was carried out on a different computer – the subsequent CO_2 rise and warming soon swamps this initial small transient.]

What is the CO_2 concentration in 2000? How does it compare with the actual concentration at this time (369.47 ppmv, observed at Mauna Loa observatory)? What is the CO_2 concentration in 2100? What has happened to air temperature? Is there a pattern to the warming?

When the experiment is complete (if time permits): From the results folder, extract the time series of atmospheric CO_2 concentration. Plot this and compare it with the historic time series of CO_2 (see above website). How well does model CO_2 compare with observed CO_2 up to 2000? Also extract the time series of NH and SH air temperature. Combine these (average them) to get global mean air temperature and subtract the initial (year 0 = 1800) value to get the anomaly (global warming). How well does model global warming compare to observed global warming in 2000 (estimated at 0.7°C)?

5. Climate Sensitivity Experiments (3.30-5.00)

Based on the experience you gained in stages 3 and 4, run a multi-centennial experiment (at least 500 years, longer if you have time – work out how long you can run for, based on the 300 years in stage 4). Specify an initial pulse of CO_2 emissions: immediately increase emissions to a large value, sustain this for 50 years, then "switch off" – i.e., back to zero, and keep emissions at zero for at least 450 years. You will see the CO_2 concentration peak at the end of the pulse, after which the climate-carbon system equilibrates towards a new "high CO_2" state. A fraction of the pulse-emitted CO_2 remains in the atmosphere on a multi-centennial timescale (note the difference between peak and final CO_2 concentration).

You should cooperate in this stage! Work in groups of ~5 pairs, each pair undertaking a different pulse experiment (agree the pulse amplitude before you start). Share the experimental results within the group, completing sufficient runs in the time available to determine the relationship between CO_2 and temperature, as outlined below.

The general concept of climate sensitivity was introduced earlier. Here we want to determine the long-term global warming as a function of the long-term CO_2 concentration. Increasing the "height" of the CO_2 emissions pulse in a range of experiments, plot the warming as a function of the ratio of increased CO_2 to initial CO_2 (modern pre-industrial = 279 ppmv). Aim to get end-of-run CO2 concentration equilibrating towards values in the range x1.5 (Pliocene?) to x8 (PETM?) pre-industrial concentration. A clear relationship should emerge, from which you can ascertain a rough functional relationship between warming and CO_2.

Caveat: full equilibrium may only be approached after around 1000 years (mixing timescale of the global ocean, with implications for readjustment of the carbon cycle), and the long-term carbon cycle continues to remove CO_2 from the atmosphere over timescales of O(10,000) years.

Hint 1 : the "equilibrium climate sensitivity" of a climate model (or the real climate system) is often defined as the rise in global-mean temperature for a doubling of CO_2.

Hint 2. Start with 20 Gtonne C per year, for first 50 years, followed by zero emissions over years 51-500.

Epilogue: This version of GENIE has been used to simulate Quaternary AMOC & climate variability, the PETM, and some aspects of the Snowball Earth. We just don't have time in one practical session to explore all these different scenarios!

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