

A Hitchhikers Guide to the Black Arts (of Earth system modelling)

Lesson #5: Greenhouse climates of the past: early Eocene



From: <http://dinopedia.wikia.com/wiki/Eocene>

Relevant reading:

Dunkley Jones, T., D.L. Lunt, D.N. Schmidt, A. Ridgwell, A. Sluijs, P.J. Valdes, and M. Maslin, Climate model and proxy data constraints on ocean warming across the Paleocene-Eocene Thermal Maximum, *Earth-Science Reviews* 125 123–145 (2013).

Lunt, D. J., Dunkley Jones, T., Heinemann, M., Huber, M., LeGrande, A., Winguth, A., Loptson, C., Marotzke, J., Roberts, C. D., Tindall, J., Valdes, P., and Winguth, C.: A model–data comparison for a multi-model ensemble of early Eocene atmosphere–ocean simulations: EoMIP, *Clim. Past*, 8, 1717-1736, doi:10.5194/cp-8-1717-2012, 2012.

0. Readme

- 0.1 You will need to download a new restart file prior to embarking on the experiments with modern ocean circulation.

Change to the `cgenie_output` directory and type (or copy and paste carefully from the PDF ...):

```
$ wget http://www.seao2.info/cgenie/labs/AWI.2017/LAB_5b.SPIN.tar.gz
```

This downloads an archived/compressed copy of the 10,000 year spin-up experiment `LAB_5b.SPIN`. Extract the contents of this archive by typing:

```
$ tar xfv LAB_5b.SPIN.tar.gz
```

- 0.2 You will also need to carry out a small update of some of the configuration files in the model code. To do this: change directory to the `cgenie.muffin` directory (not `genie-main ... yet ...`) and type:

```
$ svn update
```

Now ... change to `genie-main` directory to run the model.

1. Understanding the climate of the early Eocene

- 1.0 A previously spun-up state of early Eocene climate with cGENIE in a ca. 56 Ma configuration (LAB_5b.SPIN) is provided as a starting point. A *user-config* (LAB_5b.EXAMPLE) that continues on this climate state is run:

```
$ ./runmuffin.sh cgenie.eb_go_gs_ac_bg.p0055c.NONE LABS  
LAB_5b.EXAMPLE 10 LAB_5b.SPIN
```

(Note that once again, for speed, no carbon cycle is selected in this configuration.)

Again, as per for the late Cretaceous configuration, a configuration that includes the ocean dye (color) tracers is also provided. The corresponding *user-config* (LAB_5b.colorinjection) that continues on this climate state can be run as follows:

```
$ ./runmuffin.sh cgenie.eb_go_gs_ac_bg.p0055c.rb LABS  
LAB_5b.colorinjection 10 LAB_5b.SPIN
```

- 1.1 What to 'do' with this? Again – start by tracing and analyzing the patterns of ocean circulation in the Eocene world, as per how you did for the modern and Cretaceous system. Where does deep water form in the Eocene? Is the surface ocean circulation as expected? Can you see any patterns emerging? At least in model world – what seems to be dictating the locations of deep water formation? Does overturning and/or surface circulation appear to significantly vary as a function of continental configuration or radiative forcing? If not, why not?
- 1.2 But how do you know how close, or not, the model climate is to 'reality'?

Available from the website, on the LH side of the page under 'got data?' at the bottom (item (7)), are 2 netCDF files containing proxy sea surface temperature (SST) data re-gridded to the cGENIE model grid. One is for pre-PETM SSTs, and one for peak PETM SSTs. (The data are from *Dunkley Jones et al.* [2013].)

These netCDF files can be opened and visualized in exactly the same way in exactly the same way as per the cGENIE output files. You'll see a few (there are not many!) data points, in a sea of grey (which stands for 'no value'). (Note that it is best to turn data interpolation OFF.)

More useful ... is that the data distribution can be combined with the model ocean temperature output filed, in a difference map (see earlier for notes on creating difference maps). You can thus visualize the pattern of model-data mismatch. (Note you might want to hit 'Fit to data' to autoscale the plot, or simply pick and manually enter a +/- limit for the data plotting, perhaps ensuring it is symmetrical about zero such that red anomalies could represent proxy SST values higher than min the model, and blue point data being lower than in the model.)

Furthermore, in the Arrays tab, you can switch to a Zonal Average view rather than a Map view. (It is probably easier to visualize the model-data misfit in this way.)

- 1.3 So, starting with the pre-PETM data and given model configuration, make some assessment of how the model fits the data (or not). What might be the reason for the misfit? You might test adding, and adjusting, some of the parameter values controlling surface SST from the Cretaceous climate exercise. Can you reduce the model-data misfit?
- 1.4 Finally, the PETM SST data given in the 2nd netCDF file are from the peak of the PETM. The ocean is rather warmer as compared to just prior to the PETM. Your task is to determine (either using the default model configuration, or your adjusted configuration) much radiative forcing (parameter `ea_radfor_scl_co2`) and hence CO₂ is required to explain this warming?