A Practical Introduction to Earth System Modelling

13th-14th August 2015

School of Geographical Sciences (room 1.4n), University of Bristol

(Prof. Andy Ridgwell / University of Bristol & UC-Riverside / andy@seao2.org)

This workshop will give an introduction to and practical hands-on learning in Earth system modelling. It will provide a chance to explore the dynamics of the Earth's climate system as well as of global carbon cycling and the biogeochemical impacts of fossil fuel CO_2 emissions. The workshop will foster a critical appreciation of the nature and limitations of climate and Earth system models in trying to understand and predicting global change. But you will also see how numerical models can be utilized to address scientific questions, test hypotheses, and quantify the past and future relationship between global carbon cycling and climate and associated feedbacks. You will learn new computer skills and gain experience with some data visualization packages.

In summary:
- You will have prescribed fun.
- You will lose all respect for climate (and other complex) models.
- But … you will also appreciate how essential models are as tools for testing hypotheses, quantifying impacts, and exploring the possible behaviours of climate and carbon cycling to (e.g. human) disruption, and generally: learning how the Earth system 'works'.
- You will get a 'hands-on' appreciation of the nature (in terms of carbonate chemistry) and spatial pattern of anthropogenic ocean acidification.

There are no 'pre-requisites' in terms of computer programming skills or knowledge, and you do not have to bring a laptop.

Food and refreshments will be provided on both days. I guess that there is some inevitability that we'll head to a pub on the Thursday evening for beer/food (is there a difference?).

I suggest that we start to accumulate on the Thursday from around 10-10.30-ish in room 1.4n of the School of Geographical Sciences (University of Bristol) – see map – and start the workshop itself at 11 am. The School is in the middle of some particularly mess renovations and the way to get there may not be easy. It is going to be a sort of intelligence test: if you cannot find the room, you are clearly not to be trusted operating a computer. We'll aim to have some signs up directing traffic (you). You can also ask at Reception in the main building (just off University Road, again see map). On the Thursday we'll aim to finish around 5 pm, on Friday we'll start at 9.30, and finish mid afternoon so those of you that wish or need to escape the orbit of Bristol Friday pub time can do so. A schedule for the 2 days is attached.

Any questions – please email.

Andy (andy@seao2.org)

The course will be based around using and analysing the 'cGENIE' Earth system model (http://www.seao2.info/mycgenie.html). You will be working in groups of 2 (or 3) and will be accessing a computing cluster (deep in the basement in the School of Geographical Sciences) on which you will actually be running the model. You will hence need some means of accessing the remote computer. Unless you are some sort of wizard, I suggest either the desktop (provided, plus temporary IT account for non UoB students/staff) in the computing room we will be using, or you can bring your own laptop. If you prefer your own laptop, you'll also need some specific software on it. The exact software will depend on your operating system, but everyone will need:

1. A terminal ('shell') window. This is no problem for linux and Mac users (you already have one built in). For Windows, either download a simple (and old) SSH client (ssh-client) from my website (http://www.seao2.info//cgenie/software/ssh-client.exe) or you can get hold of e.g. PuTTY (http://www.putty.org/).

2. A sftp (secure file transfer) client for convenience (i.e. dragging and dropping files between local and remote computers, and opening files directly on the remote computer cluster). If you have installed ssh-client (Windows, above) then a sftp client is already included as part of this software. If using PuTTY (Windows) you might try downloading WinSCP (http://winscp.net/eng/index.php). For the Mac – I am told that Cyberduck is OK (there are bound to be many other alternatives). For linux, maybe FileZilla.

3. A viewer for netCDF format spatial data. A Java viewer called Panoply is provided by NCAR for all platforms – http://www.giss.nasa.gov/tools/panoply/
(Note that you will need Java installed!)

4. A simple text editor, except not the rubbish default Windows one – you need one that can display unix ASCII text without screwing it up. Options for Windows users are:
notepad++ (https://notepad-plus-plus.org/)
SciTE (http://prdownloads.sourceforge.net/scintilla/Sc355.exe)
(linux and Mac users need no special/different editor compared with your standard editor – everything will display just fine).

One slight caveat with the written instructions that you will be given is that they assume that you will be running Windows and using ssh-client (and an old version of Panoply). So you'll need to translate the instructions a little depending on your operating system.

It is also possible to install and run the 'cGENIE' Earth system model on a linux box (e.g. Ubuntu) or a Mac. Sets of instructions ('Quick-Start Guide') are available on my website: http://www.seao2.info/mycgenie.html

Note that it is not possible at this time to run cGENIE ('muffin' version) under Windows (at least, not without near infinite pain).

Also note that if you have trouble installing and running cGENIE on your own linux box or Mac, there may not be time to sort out the problem (and in any case I have no clue at all about Macs). If so, you'll have to access and run the model remotely. (There are also advantages to running on the remote cluster as you will see in due course.)

Summary: (i) A computer (Windows PC) and IT account are provided for you (== easiest). (ii) A (remote) computer cluster account is provided on which to install and run the model (== easiest). (iii) You can access, and even install, the model on your own laptop if you prefer (/dare) (== hardest).

Day 1 (Thursday 13th August) – Earth system modelling for 'newbies'[*]

START (ca. 11 am)

- **COFFEE**
  Presentation **– Course and methodology overview**
- *Session* #0 *(am)* **– Getting started**
  Accessing the computing cluster; installing and compiling *c*GENIE; directory structure ('where everything is').
  Command-line operation; how to submit jobs to a cluster queue. Use of 'restart' experiments and modelling methodologies.
  Visualization of model output: time-series and time-slice (2D and 3D) output.
- **LUNCH** (ca. 1-2 pm)
- *Session* #1 *(pm)* **– A 'real'(!) experiment**
  Setting up experiments: configuration files and setting parameter values.
  Exploring Earth system dynamics: 'Snowball Earth' and climate feedback.

END (ca. 5 pm) (+ pub)

Day 2 (Friday 14th August) – Getting your hands dirty (with carbon)

START (ca. 9:30 am)

- *Session* #2 **– 'Poking the climate beast'**
  Applying perturbations and tracing ocean circulation.
- **COFFEE** (ca. 11 am)
- *Session* #3 **– Poking the carbon cycle**
  CO_2 emissions and the spatial patterns of ocean acidification.
- **LUNCH** (ca. 1-2 pm)
- *Session* #4 **– Engineering the carbon cycle**
  Sensitivity of atmospheric $p$$CO_2$ and ocean acidification to changes in the ocean's biological pump and 'weathering'. Ocean carbon cycle geoengineering.

END (ca. 4 pm)