ENV 415 / ATM 415: Climate Laboratory, Spring 2016

Assignment 1

Answer all three questions. Due Tuesday February 9 by 10:15 am.
You may submit your answers by email (brose@albany.edu) or on paper at the start of class.

Question 1: (*Primer section 1.6, Review question 1)*

List the five reasons most persuasive, in your opinion, for building or using models. You do not
5 need to restrict your list to climate modeling but, for each of your chosen reasons, give an
example of how a model has contributed already and could help in the future.

Question 2:
Download this file (a Python tutorial written by Prof. Raymond Pierrehumbert):
https://geosci.uchicago.edu/~rtp1/PrinciplesPlanetaryClimate/Python/PyCh1Distro.pdf

3 Read the following sections and work through the Python exercises:

- 1.3 – 1.5
- 1.8.1 – 1.8.8
- 1.9
- 1.10.1 – 1.10.4

(you are welcome to work through the rest as well – you will eventually need all these tools).

Comment on something that you found surprising or interesting in the exercises.

Also describe your previous experiences, if any, with computer programming.

If you found nothing surprising or interesting in the exercises, comment on why you are so experienced with Python, and/or why it is so difficult to impress you.

12 **Question 3:**

In class we discussed a simple model for the global average surface temperature:

$$C\frac{dT_s}{dt} = ASR - OLR$$
$$ASR = (1-\alpha)Q$$
$$OLR = \tau\sigma T^4$$

where we defined these terms:

- ASR is the absorbed shortwave (solar) radiation
- OLR is the outgoing longwave (terrestrial) radiation
- T_s is the surface temperature
- $C = 4\times10^8$ J m^{-2} K^{-1} is a heat capacity for the atmosphere-ocean column
- $\alpha = 0.3$ is the planetary albedo
- $\sigma = 5.67\times10^{-8}$ W m^{-2} K^{-4} is the Stefan-Boltzman constant
- $\tau = 0.612$ is the atmospheric transmissivity
- $Q = 342$ W m^{-2} is the global average incoming solar radiation

1 a. With the parameter values given above, what is the equilibrium temperature? Solve the problem mathematically and show your work.

1 b. Would your answer in part (a) be different if the heat capacity C was larger? (e.g. because the heat penetrated twice as deep into the ocean)

c. Suppose that the sun suddenly gets brighter so that Q increases by 2%.

2 i. What is the new ASR?

ii. What is the new equilibrium temperature?

d. T_s is initially at the first equilibrium temperature when the sun brightens. After the brightening the climate system is not in energy balance so the temperature must change. According to this model, what is temperature after

i. 2 years

4 ii. 10 years

iii. 50 years

To answer this question, use numerical time-stepping. The formula we derived in class is

$$T_2 = T_1 + \frac{\Delta t}{C}\left(ASR - OLR(T_1)\right)$$

Show the Python code you used to calculate your answers. The simplest way is just to copy and paste your code into a plain text file.

2 e. Repeat part (d), but this time use a larger heat capacity $C = 8\times10^8$ J m^{-2} K^{-1}

2 f. What do your results show about the role of heat capacity for the equilibrium temperature and the rate of climate change? Give a short written answer.