MAE 119 Professor G.R. Tynan
Winter 2017
Homework 3

Assigned 27 January 2017
Due Friday 3 February 2017

Quiz 3 on Carbon Balance Model
will be Wednesday, 8 February 2017

1. Explain how you would modify the simple 0-d heat balance model we developed to explain the basic principles of climate change in order to account for two feedback effects:

    a. Increased cloud cover that might arise from increased water vapor in the Earth's atmosphere as a result of climate change, and
    b. A decrease in sea ice coverage and an increase in methane gas emission from thawing permafrost regions in the Artic.
    c. What effects would these terms have on the qualitative behavior of our 0-d model?

2. The CO_2 concentration in the atmosphere in 2017 is about 400 ppm. What mass of C and CO_2 does this correspond to? What was the preindustrial concentration of CO_2? What C and CO_2 mass does this correspond to? What is the increase in C content in the atmosphere? Using historical data, estimate the mass of C that has been injected into the atmosphere since the mid 19^{th} century when the industrial revolution began. Compare this mass with the *change* in atmospheric C mass and discuss/explain.

3. Use the simple carbon balance model we discussed in lecture and summarized in Chapter 5 of the lecture notes. The carbon source today which we take to be t=0 is about 8 GigaTonnes/year of C injected in the form of CO_2, and today the CO_2 fraction of the atmosphere is 400 ppm and the IR transmission coefficient β_{IR}=0.05. If t_{net}=100 years and Q_c is constant in time find

    a) the future CO_2 concentration in ppm assuming the source doesn't change
    b) the evolution of the IR transmission coefficient in time.

c) Find the estimated change in Earth's atmospheric and surface temperature using the simple 0-D heat balance model we developed in class. You make take $\beta_{vis} = \beta_1 = 0.5, f_{Earth} = 0.6, \alpha_1 = 0.34, \alpha_2 = 0.04$.

d) Now suppose that Q_C is growing at a rate of 3%/year. Repeat (a)-(c).

e) Referring to published results e.g. from the IPCC, how do your simple model estimates for CO2 concentration and temperature rise compare? Are they reasonably close?