MAE 118B – Emerging 21st Century Energy Systems
Professors Tynan and Buckley
Homework 2
Assigned: 22 January 2007
Due: 29 January 2007

1 Consider the crudest heat budget for the earth (without atmosphere and hydrological cycle) and assume the following dependency of the albedo on temperature: At low temperatures, much ice and clouds cover the earth, yielding a high albedo, whereas at high temperatures, the absence of ice and clouds reduce the albedo to zero. Taking the functional dependence of the visible light albedo as

$$\alpha = 0.5 \quad \text{for } T \leq 250 \text{ K},$$

$$\alpha = \frac{270 - T}{40} \quad \text{for } 250\ K \leq T \leq 270 \text{ K},$$

$$\alpha = 0 \quad \text{for } 270 \text{ K} \leq T,$$

solve for the earth's average temperature *T*. Discuss the several solutions.

2 Using the global heat budget of the earth model, complete with an atmospheric layer and a hydrological cycle, explore a worst-case scenario whereby elevated concentrations of greenhouse gases completely block the transmission of longwave radiation from the earth's surface, the intensity of the hydrological cycle is unchanged, and the anticipated global warming has caused the complete melting of all ice sheets, effectively eliminating all reflection by the earth's surface of shortwave solar radiation. What would then be the globally averaged temperature of the earth's surface? (Except for those transmission and reflection coefficients that need to be revised, use the parameter values quoted in the text.) Compare your estimate for surface temperature with the estimates of the International Panel on Climate Change (IPCC).

3 Suppose we model the transport of infra-red radiation through a simple uniform atmosphere of thickness d. If the density of greenhouse gas molecules in the atmosphere is N_{gg} molecules/m^3, and the probability for an infra-red photon to be absorbed is s (with units of m^2), then find a relation between the infra-red transmission coefficient, b, the gas density Ngg, the probability s, and the atmosphere thickness d. If the gas density is doubled, what happens to the infra-red transmission coefficient?

4 Using the relative change in infra-red transmission coefficient that you found in problem 3 above, by how much would the Earth's surface temperature change if CO2 concentrations doubled, but none of other parameters in the simple 0-D heat balance model that was introduced in lecture were changed?