Math 625/Physics 595CL – Homework 1

1) Compare the ground temperatures for "Model 2" and "Model 3" of the Earth climate system. Which is larger? Compare the temperature T_a of the atmosphere for Model 2 with T_{trop} of Model 3 for the temperature of the Troposphere. Give a mathematical proof that $T_{trop} > T_a$ for any possible choice of parameters, $\mathcal{T}_{sw}, \mathcal{T}_{\ell w}, \epsilon$ between 0 and 1. Give a physical explanation for these relationships of temperatures for the ground and atmosphere.

2) a. Venus has an average distance from the Sun of 0.72 AU (the distance from the Sun to the Earth is 1 AU). Find the solar constant F_S for Venus. Use the fact that the solar constant for Earth is 1370 W/m^2 and assume that the sun is a point source which radiates power isotropically.

b. The albedo for Venus is 0.77. Follow the derivation of "Model 1" to find the unreflected solar irradiance, F_0, at the top of the Venetian atmosphere. Also, as in "Model 1" find the effective emitting temperaurure T_e of Venus.

c. Consider a model with N layers of atmosphere. Each layer is completely transparent to shortwave (solar) radiation and completely opague to (i.e. absorbing of) longwave, thermal radiation. Use mathematical induction to show that for any N, the ground temperature T_g is given by

$$T_g = (N+1)^{1/4} T_e$$

d. Find the number of layers, N, needed in the model to get the observed average surface temperature of Venus of $735K$.