ESE 101:

Homework 5 (due November 15):

Greenhouse effect. Consider our simple model of the greenhouse effect from class. Assume an optically thin stratosphere that is isothermal at the skin temperature $2^{-1/4}T_e$, where T_e is Earth's effective temperature. Assume Earth's troposphere has a constant temperature lapse $\Gamma = 6.5\ \mathrm{K\ km^{-1}}$, and the current surface temperature is 290 K. Our simple atmosphere has only well-mixed infrared absorbers. We would like to know how it responds to changes in the concentration of these absorbers.

1. Sketch the atmospheric temperature profile with the tropopause height H_t and the emission height H_e, where the temperature $T = T_e$. Why is there a tropopause?

2. Assume the emission height H_e is the height of peak longwave emission (maximum radiative energy flux divergence). How does it depend on the concentration of absorbers?

3. How much does the surface temperature change when the concentration of absorbers is doubled and quadrupled? Why does the logarithmic dependence arise?

4. How much does the tropopause height change when the concentration of absorbers is doubled and quadrupled? Is this realistic? Discuss some of the shortcomings of this simple model.