Unit 12 ATM401, ATM601 and CHEM601

Application, analysis, and evaluation

1. All students: Apply the basic physics of energy transfer to develop a zero-dimensional energy-balance model of the temperature of the earth-atmosphere system. Show how the radiating temperature of the system depends on solar constant and the reflectivity of the system. The earth area is assumed to be $5.10 \cdot 10^{14} m^2$. Assume that the sun's energy that arrives at the outer edge of the atmosphere has an average rate of $S = 1.74 \cdot 10^{17} W$. How is this related to the solar constant? Determine the planetary temperatures for typical values of albedo of a forest ($\alpha = 0.15$), a desert ($\alpha = 0.25$), and the average planetary albedo ($\alpha = 0.3$). Comment your results.

2. Graduate students: Assume that there is a layer of pollutants of $1km$ thickness that absorbs 30% of the downward directed irradiation of $280 W m^{-2}$. Take air density to be equal to $1.29 kg/m^3$. Determine the change in temperature due to absorption in K/h.

3. Graduate students: Determine the ground surface cooling rate per hour due to radiative cooling during a clear night for over a depth of 5 cm assuming a soil heat capacity of $2.5 \cdot 10^6 J m^{-3} K^{-3}$. Assume a surface emissivity of about 0.99 and an absorptivity between 0.7 (winter time Arctic), 0.8 (mid-latitude winter), and 0.95 (Tropics) due to water vapor with effective atmospheric temperatures of $-40^o C$, $-15^o C$, and $18^o C$ and surface temperatures of $-35^o C$, $2^o C$, and $21^o C$, respectively. What assumptions do you have to make about wind? Will frost occur? By how much would sea-ice or the ocean cool under these circumstances? What will you have to change for these estimates? What do these results tell you about the climate system?

4. Undergraduate students: A polar orbiting and geostationary satellite are at 700 and 35790 km height. Calculate the long-wave radiation flux denisity from the Earth observed at the heights of the satellites' orbits. Assume a uniform effective emitting temperature of 255 and 285 K. Discuss your results.