Radiative transfer in the environment. Weitzmann, fall 2008.

Problem set I:

1. Calculate the solar constant assuming the temperature of the sun is 5800K.

2. You reached the top of the Everest with a broadband radiometer (UV to far IR). You point it at the center of the sun (your acceptance angle is small enough it is fully within the sun). Given the value of the solar constant, what do you expect the radiance reading to be? How would it compare to the radiance you will measure half way between the Earth and sun?

3. What is the yearly and spatially *averaged* broadband irradiance reaching the Earth assuming no atmoshphere?

4. Assuming no atmosphere and an Earth with an average albedo of 0.3 (that is 30% of the incident radiation is reflected, the other 70% absorbed), what should be the yearly and spatially averaged temperature of the Earth?

5. (From Light and Water, Ch. 1) As a crude approximation, the sky radiance distribution on a clear day can be represnted as a collimated direct solar beam plus an istoropic diffuse sky radiance. Let $L(\theta,\phi)$ be th edirection of the direct beam which contributes a fraction f ($0 \le f \le 1$) to the total sun-plus-sky irradiance E_d. The diffuse sky radiance contributes $1-f$ of the total irradiance. Such a radiance distribution can be written as:

$$L(\theta,\phi) = C\left[f\,\delta(\cos\theta - \cos\theta_s)\,\delta(\phi - \phi_s) + \frac{1-f}{\pi}\right],$$

where C is a constant that sets the overall magnitude of L.

(a) What are the dimensions of C?

(b) Compute E_d and E_{od} in terms of C.

(c) Modify the above equation so that $L(\theta,\phi)$ represents a direct beam plus a cardioidal background sky.

A cardioidal-sky radiance obeys:

$$L(\theta,\phi) = L_o(1 + 2\cos\theta), \qquad 0 \le \theta \le \frac{\pi}{2}.$$

Such a radiance distribution might be a better approximation for a day with a uniform overcast, but with the sun's position still discernable through the cloud layer.

(d) Compute E_d and E_{od} for the sun-plus-cardioidal-sky radiance distribution of part (c).