Applications with the Newest Multi-spectral Environmental Satellites

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21 – 27 September 2008

Homework Assignment (Due noon 26 September 2008)

1. What is the ratio of blackbody radiances at B(10 μm, 300 K) and B(0.5 μm, 6000 K)? Estimate this without calculating the radiances explicitly.

2. If the 4 μm brightness temperature is 310 K and the 11 μm brightness temperature is 290 K, what fraction of the radiance at 4 μm is due to reflected solar radiation? Use the fact that B(4 μm, T) is proportional to T^X where x ~ 12.

3. Consider an atmosphere where the temperature profile is given by T(p) = 200 + 100 (p/ps) in degrees K. The transmittance for a microwave spectral band is given by τ(p) = 1.0 - 0.7 (p/ps) . Assuming reflection is negligible at the earth surface, what is the brightness temperature observed by the microwave sensor in this spectral band? Start with the RTE to develop your answer.

4. The ocean surface at 300 K is covered by a layer of water vapor at 280 K with an optical depth of 0.05 in the infrared window (IRW) at 11 microns. The MODIS IRW measurement will be less than 300 K due to atmospheric water vapor absorption; what correction must be made to the measured brightness temperature to arrive at the correct SST? Assume the ocean surface behaves like a blackbody, express the transmittance of the water vapor $\tau = 1-\sigma$, and use the fact that at 11 microns the Planck radiance is proportional to T^4.

5. A model atmosphere consists of an upper layer with transmittance t1, a partial cloud layer with fractional area fc covered by clouds with reflectance rc in either direction, and a lower layer with transmittance t2. The earth surface has an average reflectance rs. (a) Ignoring scattering in the layers and absorption in the clouds, derive an expression for F, the fraction of solar radiation making it out of earth-atmosphere via the indicated path. (b) If t2 decreases by 1% (due to low level pollution), what is the corresponding percentage change in F?