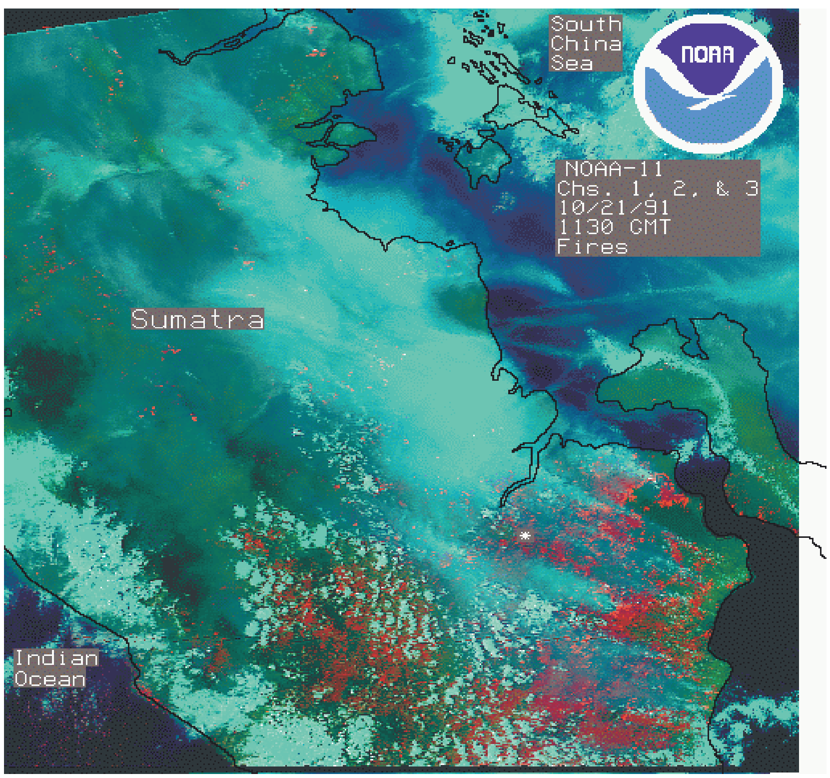
Homework #3
Radiation and Turbulence

NOTE: On all quantitative answers, give the appropriate SI units!

1. Consider the radiative interplay between the sun and the earth.
   a. Given that the solar constant is 1380 W m^{-2}, and the mean earth-sun distance is 1.50×10^{11} m, what is the total flux from the sun in Watts?
   b. What fraction of all sunlight emitted by the sun is intercepted by the earth (the radius of the earth is 6.37×10^6 m)?
   c. Calculate the equivalent blackbody temperature of the earth, assuming a planetary albedo of 0.30 (the planetary albedo is the fraction of the total incident solar radiation that is reflected back into space by soil, plants, ocean, snow, clouds, etc., without absorption). Assume that the earth is in radiative equilibrium, so that there is no net energy gain or loss due to radiation.
   d. What is the wavelength λ_{MAX} of maximum emission for a body at the earth's blackbody temperature (assume an emissivity of 1)?
   e. What is the monochromatic flux density for earth at λ_{MAX}?
   f. What is the monochromatic flux density of the sun at that same wavelength (assume the sun is a blackbody at a temperature of 5780 K)?

2. The satellite image below, from the NOAA AVHRR (Advanced Very High Resolution Radiometer) shows fires and smoke in Sumatra on October 21, 1991. The image is a false-color composite; red shows the emitted radiation at 3.7 µm, green represents 11 µm, and blue 12 µm. The small red spots are the fires (they show up better on the screen, see ftp://hpipb2.wwb.noaa.gov/pub/AVHRR/fire/sumatra.gif).
   a. Why do the fires show up so prominently at 3.7 µm?
   b. Is the smoke warmer or colder than the vegetation over land? Justify your answer.



3. Given the following information on the variation of surface albedo with LAI over a forest canopy, complete the table:

   a.

LAI	a_N	a_V	SR	NDVI	k_V	FPAR
0	0.2	0.20				
0.5	0.34	0.17				
1	0.42	0.15				
2	0.49	0.14				
3	0.53	0.13				
4	0.56	0.12				
5	0.57	0.11				
6	0.58	0.10				
8	0.6	0.09				

For : $k_V = \frac{G(\mu)}{\mu}(1 - \omega_V)^{1/2}$, assume that $G(\mu)/\mu = 1$, and that $\omega_V = a_V$.

   b. At approximately what LAI is 90% of PAR absorbed? 99%?

4. You know the following conditions at the top of the constant stress layer:
   z=10 m, u=10 m s^{-1}, θ=283 K, q=0.003 kg/kg, ρ=1.2 kg m^{-3}:
   a. The roughness length z_o = 1 m. What is the frictional velocity?
   b. What is the drag coefficient?
   c. Given that the roughness length for heat and moisture is 0.3 m, what is C_H ?
   d. What are the aerodynamic resistances for momentum and heat?
   e. At the bottom of the constant stress layer the potential temperature is 284 K. What is the sensible heat flux across the layer, and in what direction? (c_p=1010 J kg^{-1} K^{-1})
   f. What specific humidity q_o would be necessary for the latent heat flux to equal the sensible heat flux? (Note: you must multiply E_o by the latent heat of vaporization 2.45×10^6 J kg^{-1} to compare them).