HOMEWORK FOR REMOTE SENSING SEMINAR
Menzel / Antonelli
Bertinoro, Italy
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1. Concerning Planck's radiation law.
(a) $B(\nu,T)$ versus ν peaks at 500 cm-1; what is the temperature of the blackbody?
(b) At what wavelength λ does $B(\lambda,T)$ peak when viewing the same blackbody?
(c) By what percentage does the irradiance of this blackbody change when the temperature increases by one percent?
(d) Given $B(\lambda,T) = c_1 / [\lambda^5 (e^{c_2/\lambda T} - 1)]$, what is the Rayleigh Jeans expression for blackbody radiance valid for $\lambda T > 10$ cm*K?

2. What is the ratio of the blackbody radiances, B(10 um, 300 K) and B(0.5 um, 6000 K)?

3. A geostationary satellite senses visible (.45 to .55 um) and infrared (9.95 to 10.05 µm) radiation. (a) Determine the ratio of the visible to infrared radiance detected; (b) What is the ratio of visible to infrared irradiance detected? Use the following information as necessary.

visible bandwidth = infrared bandwidth = .1 micron,
vis detector area = IR detector area = .5 x 10-4 m2,
vis FOV = IR FOV = 4 x 4 km2,
r(visible reflectance at earth sfc) = .5,
T(sun) = 6000 K, T(earth sfc) = 300 K,
R(sun) = 7 x 10+8 m,
R(sun-earth) = 1.5 x 10+11 m,
R(earth-sat) 3.6 x 10+7 m .

Explain any assumptions or approximations.

4. (a) The GOES infrared window from geostationary orbit at 36,000 km detects the earth radiance from a surface at 300 K in the infrared window between 890 to 980 cm-1. For simplicity assume constant radiance over this spectral interval to be 120 mW/m2/ster/cm-1. How many 10 micron photons hit the detector every 180 microseconds, if the field of view is 4 km in diameter and the detector surface area is .5 x 10-4 m2? (b) If this were polar orbit at 800 km, what would your answer be? Remember that Joules constant $h = 6.63 \times 10^{-34}$ J s and the energy of one photon is given by hf..

5. Assume that the surface of the earth acts like a blackbody with surface temperature 300 K, that the average albedo of the earth-atmosphere system for solar radiation is 30%, and that the atmosphere is transparent to solar radiation: How much does the absorptance to longwave radiation have to change to cause a 1 K increase in the surface temperature?

6. The distance between the earth and the sun varies about 3.3% between a maximum in early July and a minimum in early January. What is the corresponding seasonal change in effective temperature? Assume the earth albedo is 30%.

7. The average CO2 concentration in the atmosphere varies by about one percent annually (in part due to foliage release in the autumn). Using the Stefan-Boltzmann law and assuming that the effective temperature of the earth-atmosphere system is 280 K, determine the associated temperature change of the earth-atmosphere system.

8. A hot plume of industrial waste is obstructing the view of an infrared radiometer into the distance. Thus the radiometer senses a hotter temperature. What is the difference of the radiances sensed by the

radiometer when viewing a clear FOV and then a plume contaminated FOV? Use the indicated transmittances and blackbody radiances for background, plume, and foreground to calculate your answer.

	Background	plume	foreground
Temperature, T (degrees K)	Tb=300	Tp=340	Tf=300
Planck Rad, B (mW/m2/ster/cm-1)	Bb=115	Bp=195	Bf=115
Transmittance, τ (dimensionless)	τb=.9	τp=.3	τf=.9

9. In a cloud free region over the ocean, the infrared window is being used to estimate sea surface temperature. If volcanic ash of .02 optical thickness in the longwave infrared window and temperature Tc = 220 K obscures the ocean, what error is introduced to the sea surface temperature estimate Ts = 300 K? Express the transmittance of the volcanic ash τ = 1-σ, and use the fact that at 900 cm-1 the Planck radiance is proportional to T^4.

10. (a) Give the definition of the radiance L emitted by a surface S_0.
(b) Which are the variables affecting the radiance's value emitted by the extended surface S_0?
(c) Consider a sensor of area A at a distance R from the centre of S_0. The geometry is shown in the figure below. Write down the equation describing the flux impinging the sensor.
(d) Determine the radiance value when the surface is homogeneous and emits isotropically as a grey body (emissivity ε=0.98) at 280 °K for an area S_0 of 1 km^2. The sensor range goes from 50 to 2400 cm^{-1} [4.2-200 µm]. Detector area A_0= 0.5x10^{-4} m^2. R=3.6x10^7 m. θ=45° Ψ=30°