

Name:

MSC 409 Final May 9, 2006

Multiple Choice: (30 pts total)

1. The radiance incident upon a flat surface of unit area (decreases, remains constant, increases) with increasing zenith angle.
2. If the Sun were twice as far away from the Earth as it is at present, the solar constant would be (one-quarter, one-half, equal to, twice, 4 times) its present value.
3. If the Sun were twice as far away from the Earth as it is at present, and its surface temperature were twice what it is now, the solar constant would be (one-quarter, one-half, equal to, twice, 4 times, 8 times) its present value.
4. At large distances, the Sun's (radiance, irradiance, radiance and irradiance, neither radiance nor irradiance) is/are approximately independent of distance from the Sun.
5. The optical thickness of the earth's atmosphere is larger in the ("window" region near 8 micron, CO₂ absorption region near 15 micron).
6. A halo close around the Sun is produced by (aerosols, cloud droplets, raindrops, ice crystals).
7. Rainbows are most striking when produced by (small raindrops, large raindrops, graupel, ice crystals).
8. If one is looking towards a setting Sun, aerosols are most clearly visible for values of the asymmetry parameter g of (0.4, 0.6, 0.8).
9. A thin cloud has a liquid water content of 30 g m^{-2} , and consists of droplets of 10 micron. If the liquid water content stays constant, but the drops coalesce to make larger droplets of radius 20 micron, the total optical thickness of the cloud will be (1/4, 1/2, 1, 2, 4) times the original optical thickness.
10. The reflectance of the cloud indicated in 9. will (increase, decrease, remain the same) when viewed from above.
11. Clouds over a bright surface will appear (brighter, darker) from below than over a dark surface.
12. Mie scattering occurs when particles are (much smaller, similar, much larger) than the wavelength impinging upon them.
13. Radiative transfer often creates temperature inversions with bases at (cloud top, cloud base).
14. What combination of properties of a gas, indicated below, are most conducive to a warmer atmosphere?
 - a. Strongly absorbing at solar wavelengths, strongly absorbing in the infrared
 - b. Strongly absorbing at solar wavelengths, weakly absorbing in the infrared
 - c. weakly absorbing at solar wavelengths, strongly absorbing in the infrared
 - d. weakly absorbing at solar wavelengths, weakly absorbing in the infrared
15. (Incoming solar, outgoing terrestrial) radiation at the top of the atmosphere, averaged over the year, exhibits a larger equator-to-pole gradient.

Short Answer: (40 pts total)

1. An increase in the fractional area of the earth's surface covered by clouds could produce either a warming or a cooling depending upon the levels at which it took place. Explain.

2. The rate of radiative energy emitted by a unit area of the Sun over a wavelength band in the IR near 15 microns is (less than, comparable to, greater than) the rate emitted by a unit area of the earth over the same band. Explain your choice,

3. Write down and describe the 3 parameters that describe the optical properties of aerosols and clouds. Why are gases not described this way ?

4. Why is the sky blue ?

Numerical Problems. Show your work. (35 pts total)

1. The planet Saturn has these attributes: an albedo of 0.5, a mean surface temperature of 143 K, a distance from the Sun of 9.5 multiple Earth-Sun distances, and a mean diameter of about 115,000 km. The flux density of solar radiation incident upon the Earth is 1368 W m^{-2} .

a) What is the flux density of solar radiation incident upon Saturn ?

b) what is the blackbody temperature of Saturn ?

c) What is the wavelength of maximum emission from Saturn ?

2. A dusty Saharan Air Layer is developing over the desert. The dust has an optical thickness of 3.0, a single-scattering albedo of 0.5, and an asymmetry parameter of 0.7. The desert has an albedo of 0.6.

a) How much of the direct solar beam is transmitted through the dust layer ?

b) How much of the direct solar beam is reflected off of the desert surface ?

c) How much of the direct solar beam is absorbed by the aerosol layer ?

Now assume a cirrus cloud of optical depth 1 passes overhead, with a single-scattering albedo of 0.9 and an asymmetry parameter of 0.85.

d) How much of the direct solar beam is transmitted through to the ground ?



*"I can remember when there was
nothing here but polar ice."*

Planck's Law: $B = c_1 \lambda^{-5} / \pi (\exp(c_2 / \lambda T) - 1)$
Boltzmann constant = $5.67 * 10^{-8} \text{ W m}^{-2} \text{ K}^{-4}$
Wien's Law: $\lambda_m = 2897 / T$

