

CHAPTER 3. Energy Balance and Temperature

Review Questions:

1. Explain how the absorption and scattering of radiation in the atmosphere affects the receipt of solar radiation at the surface.

Particulates suspended in the atmosphere serve to reduce the amount of radiation reaching the surface. This is accomplished by absorption, reflection, and/or transmission of available energy by the suspended aerosols.

2. Which two gases are most effective at absorbing longwave radiation?

Water vapor and carbon dioxide are the primary longwave absorbers in the atmosphere.

3. How do specular reflection and diffuse reflection differ?

Specular reflection is reflection of energy as an equally intense energy beam. Diffuse reflection reflects energy in such a way as to disperse that energy into many weaker wavelengths. This is scattering.

4. What does the term albedo mean?

Albedo refers to the percentage of reflectivity of an object. High (low) albedo relates to light (dark) colored objects which reflect a high (low) percentage of energy.

5. What characteristics of Rayleigh scattering cause it to create a blue sky?

Rayleigh scattering scatters energy forward and backward by scattering agents which are smaller than the energy wavelengths. As such, shorter wavelengths are favored, or scattered more than longer ones. A blue sky results as blue resides is primary short wavelength of energy along the visible spectrum.

6. What properties of Mie scattering distinguish it from Rayleigh scattering?

Rayleigh scattering refers to the scattering of energy by objects smaller than the wavelength of radiation. This is done mainly by atmospheric gases. Because the scattering agents are so small there is a scattering bias toward shorter wavelengths.

Mie scattering primarily involves suspended particulates which are much larger than gases. These particulates scatter energy in a forward manner resulting in gray skies when large amounts of particulates are present.

7. Why are overcast days typically gray?

Mie scattering causes energy scattering in a forward manner resulting in gray skies when large amounts of particulates are present. Also, nonselective scattering involves equal

scattering of visible wavelengths by large objects such as water drops. This normally produces a white cloud. However, when large amounts of cloud are present, energy becomes depleted through the cloud leaving a grayish cloud overhead (or in extreme cases, a very dark cloud base).

8. What is the numerical value of Earth's planetary albedo?

30%

9. Which type of scattering accounts for the majority of Earth's planetary albedo?

Rayleigh scattering.

10. Describe quantitatively how much solar radiation is absorbed and reflected by Earth's atmosphere and surface.

About thirty percent of incoming solar radiation is directly reflected by Earth's albedo. About one half of the solar radiation available at the top of the atmosphere actually reaches the Earth's surface (about 45%). The remainder is either directly absorbed or reflected by the atmosphere and objects suspended in the atmosphere.

11. What is the atmospheric window?

The place where the space shuttle enters the atmosphere - just kidding. Terrestrial radiation peaks between 8 and 12 μm a region of the spectrum not absorbed by atmospheric gases. These wavelengths pass directly to space with the phenomena termed the "atmospheric window".

12. Why is it incorrect to state that longwave radiation bounces back and forth between clouds and the surface?

Longwave radiation is actually absorbed by clouds which then re-radiate the energy back towards the surface where it is absorbed again.

13. Describe sensible and latent heat.

Sensible heat is heat energy that is readily detected. This relates to an object's specific heat and mass. Latent heat is energy required to induce changes of state in a substance. Latent heat of evaporation is energy stored in water vapor. This energy is released to the atmosphere upon condensation.

14. How do the net input and output of radiation vary with latitude?

Areas between 38° N and S experience net energy surpluses while pole ward positions experience net deficits. However, the margin between net gains and loses migrates seasonally. For the summer (winter) hemisphere, net gains (loses) occur pole ward of

about 15°.

15. Which two processes transport energy from zones of radiation surplus to zones of radiation deficit?

Temperature inequalities create atmospheric pressure differences which cause winds and currents which transport energy latitudinally.

16. Why does the term greenhouse effect inaccurately describe how the atmosphere is heated?

A greenhouse stems heat loss by limiting convection, a regular process in earth's atmosphere. So the name is misleading.

17. Discuss how geographic factors such as latitude and altitude influence the distribution of temperature across Earth's surface.

Low latitude locations experience only small temperature changes through the year as these locations receive nearly constant amounts of solar radiation. Locations farther poleward experience larger annual temperature ranges as solar radiation values flux due to Earth-Sun geometry. Because temperatures typically decrease with increasing altitude in the troposphere, higher altitude locations are typically cooler than lower altitude locations. However, because altitude refers to height above mean sea level without considering the elevation of landmasses below, this may be misleading. In sum, locations far above Earth's surface experience minimal fluxes in temperature as compared to locations directly below, and nearer, the Earth's surface.

18. Describe the horizontal and vertical scales on Stüve diagrams.

The horizontal scale of a Stüve diagram depicts air temperature. The vertical scale depicts pressure in mb. This allows plotting of temperature as a function of the pressure level, not the height above the surface, which allows a more direct application of meteorological laws than other diagrams.