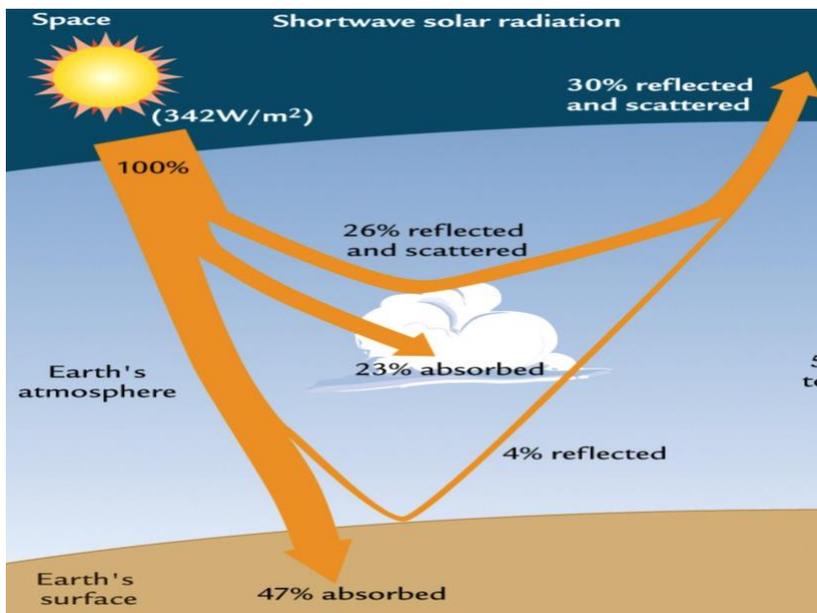


ERTH 260: Homework #8
Radiation Budget Concepts and Thunderstorm Development
(Due Wednesday 9 April 2018; 100 points)

1. The updrafts that lead to thunderstorms mostly (but not always) begin forming during daylight hours. Such daytime updraft formation is related to the atmosphere being heated from beneath by conduction.

How does the shortwave radiation budget (schematically shown below) suggest that the atmosphere is heated from beneath? (Please answer in detail in a complete paragraph). (25 points)



The amount of energy that passes through the top of the atmosphere is quantified by the solar constant. All of this energy is available to be potentially absorbed and converted to internal energy (vibrations) by molecules in the atmosphere and the earth's surface. However, because the gases in the atmosphere are selective absorbers and because a portion of the energy is either reflected or scattered by the clouds, dust, gasses in the atmosphere, about 23% of the solar constant is absorbed by the atmosphere and 47% by the earth's surface. Since absorption implies heating, it's clear that the earth surface is heated more than the atmosphere is by direct absorption of solar radiation. Thus, the earth's surface is warmer than the atmosphere, and heats the atmosphere by conduction from beneath.

2. We have learned that the temperature changes observed at the surface of the earth due to the uniform receipt of solar radiation are different depending upon a number of factors including (i) albedo, (ii) specific heat, and (iii) inclination of absorbing surface.

Explain the following, assuming the stability of the atmosphere is everywhere the same and that there is NO horizontal wind. Please remember to link your answers in detail to one of the concepts discussed earlier in the class and listed above. (Please answer in detail in a complete paragraph). (25 points for each answer)

- (a) The first cumulus clouds begin developing over mountainous areas shortly after sunrise in regions with plains or valleys next to mountains;

The sun's first rays in the morning strike the mountain slopes at nearly right angles, and the valleys and surrounding plains either receive solar energy at an oblique (spread out) angle or are in darkness. Thus, the mountain slopes and peaks heat up rapidly and the first cumulus clouds appear there.

- (b) In a flat region made up of alternating granite surfaces next to wet meadows, the first cumulus clouds begin developing over the granite areas around noon;

The specific heat of rock surfaces, being made of metal, is much lower than that of areas saturated with water. Thus, for a given absorption of solar radiation, even if that radiation is intense, the rock surfaces will heat up more than the surrounding meadows and the first cumulus clouds will appear over the rock surfaces.

- (c) In a flat area made up of dark colored rock alternating with lighter colored rock, the first cumulus clouds begin developing around noon over the dark colored surfaces.

The darker the color the lesser the albedo. This means that dark surfaces absorb absorb more of the incident radiation than light colored surfaces. Thus, the first updrafts begin forming over the darker colored surfaces.