AOS 100

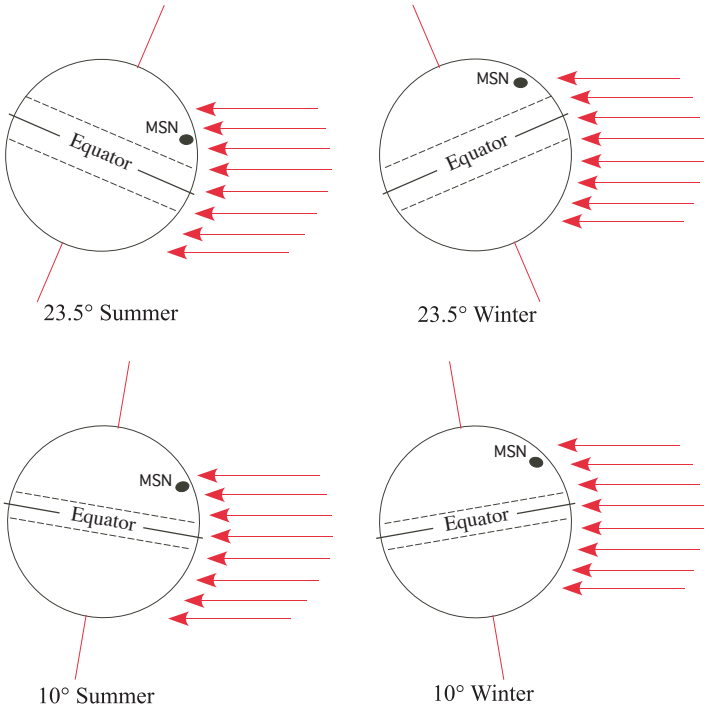
Homework 3 Answers

Spring 2018

1) (a) Carbon dioxide (CO2) has the property that it is transparent to visible light and only translucent to infra-red (IR). Thus, CO2 molecules in the atmosphere are particularly good at absorbing outgoing IR energy before it escapes to space. By Kirchoff's Law, since CO2 is a good absorber of IR, it is also a good emitter of IR and it emits IR in all directions. Half of all directions have a component directed downward to the surface and so the overlying atmospheric CO2 accounts for a stream of radiant energy incident on the surface of the Earth that helps keep the temperature of the planet much warmer than it would be in the absence of an atmosphere.

(b) A warmer planet would likely enhance evaporation of liquid water from the oceans, leading to an increased amount of invisible water vapor in the atmosphere compared to present day conditions. Water vapor is also a potent greenhouse gas and so an increased amount of it might further contribute to warming via absorption and re-radiation of IR energy toward the surface of the Earth.

2) a) If the axis of the Earth were tilted at only 10 instead of the current 23.5 our seasons would be quite different than they are now. First of all, the tropics would extend only from 10N to 10S (instead of the current 23.5N to 23.5S) while the Arctic Circle would be at 80N (instead of the current 66.5N). Madison summers would experience a greater angle of incidence than at present and so the absorption of solar radiation would be smaller in this alternate world. That would lead to cooler summers. During winter, the angle of incidence would be higher than presently and so we would absorb more energy on a typical winter day in the hypothetical world. Consequently, our winters would be milder than they are at present. A diagram on the next page helps to illustrate these differences.



(b) In this alternative world, the Arctic Circle would be at 45N. Since Winnepeg's latitude is 49.9N, it is north of this hypothetical Arctic Circle and so would not see the sun rise on Christmas Day in such a world since Christmas is just days past the Winter Solstice.

3) Albedo describes the percentage of reflection of radiation from a surface. Clouds are very reflective of solar radiation and so increased cloud cover would lead to larger reflection of solar energy away from the surface. This would force a cooling of the planet. However, clouds are also good absorbers of IR energy (and so good emitters as well). Thus the presence of a cloud deck tends to keep a location warmer than it would be without clouds - especially true at night for low clouds. So, increased cloud cover, depending on the exact nature of the clouds, might actually contribute to a warmer planet by ensuring that overnight lows are made milder.

4) On the first day, the incoming solar radiation is first spent on evaporating the water manifest in the dew drops. Thus, a certain amount of energy is spent on the first day that can be used, on the second day, to heat up the ground itself. Since more energy is given to heat the ground on day 2, the air temperature above the ground will also warm more rapidly on that day.