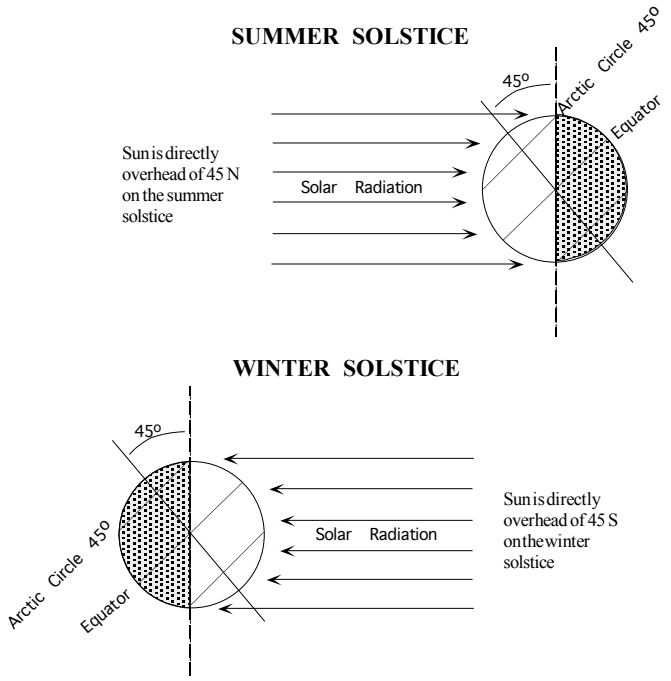
AOS 100/101
Spring 2017

SOLUTIONS
HOMEWORK #3

1) (a) If the Earth's axis were tilted at 45° instead of the current 23.5°, the summer sun over Madison would be higher in the sky resulting in more intense insolation. Also, the days would be longer. This combination of circumstances would lead to greater absorption of solar radiation than at present. Thus, the summers would likely be warmer than they are now.

The winter sun would be lower in the sky and the days shorter. As a result, the winters would be colder than at present in Madison. See the accompanying diagrams below.



(b) As seen in the above figure, near the summer solstice the sun would shine directly overhead at 45°N at noontime. The latitude of Madison is 43.07°N so your shadow would point south at noontime on June 21 under these hypothetical conditions.

2)

(a) CO2 absorbs IR radiation very well. If there is a lot of CO2 in the atmosphere, then a large fraction of the outgoing IR energy emitted by the surface of the Earth will be absorbed by the atmosphere and then re-emitted. Half of that re-emission is directed back toward the surface leading to a warmer surface than would otherwise be the case. If the atmosphere had less CO2, there would be less absorption and re-emission of outgoing IR so the planet would be cooler. Therefore it is not surprising that the

concentration of CO2 was lower during the last ice age – a time at which the Earth was considerably cooler than now.

(b) Increased snow and ice cover would increase the albedo of the Earth, thus reducing the amount of solar radiation that is actually absorbed at the surface. This effect would lead to a COOLING of the planet. This cooling would serve to reinforce the widespread coverage of snow and ice which would further increase the albedo which, in turn, would further reduce the amount of solar radiation aborbed at the surface in what is known as a feedback loop.

3)

As soon as the sun rises, there is an input of solar radiation to the Earth and atmosphere. The ***use*** of this energy will be different on the two days described in the problem. On the first day, some of this energy will be used to sublimate the frost from the grass and the rest will be used to warm the air. On the second day, some of the energy will be used to evaporate the dew from the grass and the rest will be used to warm the air Since it takes more energy to sublimate ice than the evaporate water, there is more energy left over for warming the air on the second day and, as a result, the second day will have the higher temperature one hour after sunrise.

4)

On average, the temperature decreases with increasing height in the troposphere. As a consequence of this fact, low clouds will always be warmer than high clouds. The Stefan-Boltzmann Law tells us that the amount of energy an object emits depends upon the fourth power of its temperature. Therefore, the low clouds – which are warmer – will emit more radiation than the high clouds. This radiation is emitted in all directions – half of which point toward the ground. Since the low clouds send more radiation toward the ground by virtue of their larger emission, they will have a greater warming effect on the surface than will the high clouds.