Atmospheric Sciences 111 Homework 1 Due Tuesday June 29

Covering material from week 1 lectures and *Rough Guide* pp. 3-30.

Solar Radiation

1. Explain why summers are hotter than winters. Do you expect summer-winter differences to be more or less pronounced near the equator compared to higher latitudes (higher latitude means closer to the North or South Pole)? Why? (5 points)

2. What is albedo? (1)

    a. Why is albedo important for climate? (2)

    b. Imagine that global warming causes global cloud cover to increase. Would planetary albedo increase, decrease, or stay the same? Assume everything else is unchanged. (1)

    c. Would global warming increase, decrease, or stay the same (relative to what it would do if there was no change in cloud cover) as a consequence of 2b? (1)

The Greenhouse Effect

Recall: global energy balance means the total energy the earth receives from the sun equals the total energy that it radiates away. ($E_{in} = E_{out}$) The total energy the Earth

receives from the sun depends on the sun itself (intensity, distance from the Earth, etc) as well as Earth's albedo. The total energy that the Earth radiates away is primarily due to its temperature.

3. If the sun suddenly started shining more brightly, increasing E_{in}, how would Earth's climate respond to maintain energy balance? (2)

4. In the real world, E_{in} is nearly constant. If Earth had no atmosphere, all of the radiation emitted from Earth's surface would escape to space, and the temperature of the surface would be such that E_{out} is equal to E_{in}.
    a. If there were no atmosphere, would this surface temperature be warmer, colder, or the same as it is now? (1)

    b. Now imagine an atmosphere so full of greenhouse gases that *all* of the radiation emitted from Earth's surface is absorbed in the atmosphere. Now the *atmosphere*, rather than the surface, must maintain energy balance by radiating E_{out} (longwave radiation) to space. How might you expect the average temperature in the upper atmosphere, where the longwave radiation is escaping to space, to compare to the *surface* temperature in the no-atmosphere example in 4a? Why? (3)

    c. Because most solar (shortwave) radiation is absorbed at Earth's surface, the surface is warmer than the atmosphere. What does this suggest about the *surface* temperature in case 4a compared to 4b? Explain. (3)

d. Our atmosphere has some greenhouse gases, and *most*, but not all, of surface radiation is absorbed in the atmosphere. Adding more greenhouse gases increases the height in the atmosphere at which longwave radiation can escape to space. Also, the temperature of (most of) the atmosphere decreases with height. With this information, and using the simplified example above, explain why adding greenhouse gases to the atmosphere increases the surface temperature. Feel free to draw a diagram to help your explanation. (4)

Discussion Question

5. Please write down at least one question from this week's material that you would like to discuss on Friday. This may be on a topic you don't feel you understand well enough, or it may be a topic you found interesting and would like to discuss more. (2)