Name: ____

Date: ____

Chapter 2: Solar Energy, Seasons, and the Atmosphere

Solar energy at the top of the atmosphere sets into motion the winds, weather systems, and ocean currents that greatly influence our lives. This solar energy input to the atmosphere plus Earth's tilt, orientation, revolution, and rotation produce daily, seasonal, and annual patterns of changing daylength and Sun angles.

The periodic rhythms of warmth and cold, dawn and daylight, twilight and night have fascinated humans for centuries. In fact, many ancient societies demonstrated a greater awareness of seasonal change do than modern peoples, and formally commemorated natural energy rhythms with festivals and monuments. Presently, warm-season length is on the increase worldwide in response to global temperature change.

Insolation cascades through the atmosphere toward Earth's surface, powering the physical systems in the atmosphere, in the oceans, and on land—varying through the seasonal changes just discussed. Along the way the atmosphere works as an efficient filter, removing harmful radiation from sunlight. Let's now examine the seasonal changes and the filtering effect of our unique atmosphere.

This exercise will introduce you to shifting patterns of solar energy, seasons, and the atmosphere. After completing these exercises, you should be able to:

- ***Define*** solar altitude, solar declination, and daylength and ***describe*** the annual variability of each—Earth's seasonality.
- ***Describe*** conditions within the stratosphere; specifically, ***review*** the function and status of the ozonosphere (ozone layer).

Download the solar.kmz file from www.mygeoscienceplace.com and open it in Google Earth™.

Exploration 1: Net Radiation

After reviewing the section "Global Net Radiation" in your text, double click on the Daily Net Radiation placemark and make sure that its box is checked. This animation shows changing patterns of monthly clear-sky average net radiant flux from July 2002 through June 2004 as measured by the CERES instrument. The regions that are red to yellow are the regions of maximum heating, and the blue regions are regions of maximum cooling.

1. Given what you know about the orbit of Earth around the Sun, where and when would you expect to find the highest radiation values? Where and when would you expect to find the lowest radiation values? *Personal answer, but highest values should be by the equator and lowest values should be at the poles.*

2. Where and when do you find the highest radiation values? What is the highest radiation value in watts/m^2? *50° North and South around the time of their summer solstices. 200 W/m2*

3. Where and when do you find the lowest radiation values? What is the lowest radiation value in watts/m^2? *The poles around the time of their winter solstices. -200 W/m2*

4. Describe the pattern of net radiation over the course of a year. Which regions show consistent cooling? The regions of net input follow the sub-solar point. The Sahara desert and the Arabian peninsula show consistent cooling. The regions of net input follow the sub-solar point. The Sahara desert and the Arabian peninsula show consistent cooling. The regions of net input follow the sub-solar point. The Sahara desert and the Arabian peninsula show consistent cooling. *The regions of net input follow the sub-solar point. The Sahara desert and the Arabian peninsula show consistent cooling.*

5. Which regions show consistent warming? *The equator shows consistent warming.*

6. The location of the subsolar point travels from 23.5° north to 23.5° south, for a total of 47° of movement. After viewing the animation several times, pause it during January and July. What is the latitude of the maximum heating in January? in July? How many degrees does the region of maximum heating travel across during the year? *January 50° N, July 55° S. 105° of annual travel.*

7. Given that the regions of maximum heating are farther apart than the regions of maximum solar energy, heat is obviously transferred from the equator toward the poles. According to the text, what heat engine transfers heat energy from the tropics to the poles? *Ocean currents, prevailing winds, storms, and hurricanes.*

8. Freeze the animation on March 20, 1993. (A) What is the radiant flux for the Sahara desert (Mali, Algeria, Niger, Chad, Libya, Egypt) in watts/m^2? *-50 W/m^2*

(B) How does this value compare with sub-Saharan Africa (Cote d'Ivoire eastward to the Central African Republic) and the Mediterranean? *+75 W/m^2*

(C) How do you explain the difference in radiant flux? *The desert has very dry conditions resulting in lower amounts of latent heat expenditure. The lack of water vapor in the atmosphere allows great amounts of heat absorbed during the day to return back out to space at night.*

Exploration 2: Solar Altitude and Declination

After reviewing the section "The Seasons" in your text, double click on the Analemma placemark and make sure that the box is checked to display its features. In this exploration you will find locations based on their longitude, as well as finding the latitude and longitude of locations. The analemma is a graphic depiction of the declination of the subsolar point over the course of a year. The analemma shows the latitude of the location where the rays from the Sun are striking the surface of Earth at a 90° angle. The location of the subsolar point is shown for the first of each month, as well as for the solstices and equinoxes. When you click on one of the dates in the Analemma folder the pop-up balloon will show the date and location of the subsolar point for that date.

1. What is the location of the subsolar point on the date closest to your birthday? *Personal answer*

2. What is the location of the subsolar point on the date closest to today? *Will depend upon time of year*

3. (A) How many degrees of latitude does the subsolar point travel across from December 1st to January 1st? *~1°*

(B) From March 1st to April 1st? *~12°*

4. (A) How does this affect the amount of energy received at the tropics compared with the amount of energy received at the equator? *The tropics receive a great deal more energy than the equator due to the longer length of time the subsolar point spends directly over the tropics.*

(B) Which location would you expect to receive more energy during the year? *The tropics receive 2.5X more energy than the poles.*

Uncheck the box for the Analemma placemark and click on the radio button for the Seasons placemark. Select the Sun from either View >Sun or from the toolbar. Double click on the Spring Solstice placemark and make sure that its radio button is displayed. As you double click on each season the circle of illumination will spin rapidly and stop at the correct position for each season.

5. Describe the changing angle of the circle of illumination during the year. *The subsolar point shifts from the Tropic of Cancer in the summer to the Tropic of Capricorn in the winter. During the summer the antarctic is in perpetual night, while the arctic in in perpetual day.*

6. (A) Where would you go if you wanted to experience 24 hours of daylight? *Poleward from the arctic or antarctic circles.*

(B) 12 hours of daylight every day? *Right on the equator.*

Exploration 3: Ozone Depletion

After reading the focus study section "Stratospheric Ozone Losses" in your text, double click on the Global Ozone placemark. This placemark features an animation of global ozone levels over several years.

1. (A) What seasonal patterns do you notice regarding ozone levels? *Ozone depletion peaks in October - the antarctic spring, and levels are highest at the end of the antarctic summer.*

(B) Which month has the lowest ozone levels over Antarctica? What season is that in the southern hemisphere? *See above.*

2. Which month has the highest ozone levels over Antarctica? What season is that in the southern hemisphere? *June. Winter*.

3. Compare the ozone levels over the Arctic with those over Antarctica. What might explain the difference between arctic and antarctic ozone levels? *Arctic levels are much higher than antarctic, due to the lower temperatures of the antarctic stratosphere and the presence of polar stratospheric clouds.*