ACTIVITY Sunlight Throughout The Year

Upon completing this activity, you should be able to:

- Investigate the receipt of solar energy over the period of a year at equatorial, mid-latitude, and polar locations.
- Describe annual solar radiation patterns at different locations and relate them to the astronomical factors that cause them.
- Estimate and compare average daily radiant energy totals received at a mid- latitude location on the first days of the seasons.

Introduction

All weather and climate begin with the Sun. Solar radiation is the only significant source of energy that determines conditions at and above the Earth's surface. The Earth receives about 1 / 2,000,000,000 of the Sun's radiant energy production.

The average amount of solar radiation reaching the Earth's orbit (top of the atmosphere) and falling on a flat surface perpendicular to the Sun's rays at that distance is about 2 calories per square centimetre per minute. This rate is called the solar constant.

However, the amount of solar radiation that reaches the Earth's surface can be quite different. The nearly-spherical Earth, rotating once a day on an axis inclined as it is to the plane of its orbit, presents a constantly changing face to the Sun. Everywhere on Earth, the path of the Sun through the sky changes during the year. Everywhere on Earth, except at the Equator, the lengths of daily daylight periods change.

In addition, the atmosphere acts to reflect, absorb, and scatter the solar radiation passing through it. Clouds, especially, can reflect and scatter much of the incoming radiation.

The purpose of this activity is to investigate the variability of sunlight received at the Earth's surface over the period of a year.

Materials

- Sunlight and Seasons diagram (appearing on page 3 of Teachers Guide)
- pencil

Procedure

Examine the graph on page 12 entitled Variation of Solar Radiation Received on Horizontal Surfaces at Different latitudes.

- Data points plotted on the graph represent solar radiation received daily on horizontal surfaces averaged over each month for equatorial, mid-latitude, and polar locations. These values were determined from actual observations and include the effects of clouds.
- Time is plotted along the horizontal axis while average daily incident radiant energy in calories per square centimetre per day is plotted vertically.
- The curved line connecting adjacent months of average daily radiation values for each location is called the Annual Solar Radiation Curve.
- Note that December appears twice to more clearly display the annually repeating radiation cycles.
- Note that at the South Pole (90 degrees South latitude) the sun rises on or about September 23 and sets on or about March 21.

Questions

1. At which latitude shown does the rate at which solar energy is received vary the least throughout the year______________.

2. The annual radiation curve for Singapore shows two maxima and two minima even though the daily period of daylight remains nearly 12 hours throughout the year. Explain the astronomical cause of the two maxima and minima by referring to Fig. 2(a) in the Sunlight and Seasons diagram.

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3. Refer to Fig. 2(b) in the Sunlight and Seasons diagram. At such a middle latitude location, both the path of the sun through the sky and the daily length of daylight change from day to day. Use these two factors to explain why during the May-August period the mid-latitude location receives more solar radiation on a daily than does the equatorial location.

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4. Refer to your graph. At which latitude is there an extended period of darkness over the year?_____________. How long is it? __________________.

5. On your graph, the maximum daily solar radiation amount for Brockport, NY occurred in late June. Why does it peak six months later at Antarctica?

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6. Draw and label an estimated annual solar radiation curve for the North Pole. Assume North and South Pole radiation values to be the same, but reversed, over the period of a year. Fill in the North Pole (NP) column of the radiation table and then draw the North Pole curve.

7. Imagine you are the observer in Fig. 2(c) of the Sunlight and Seasons diagram. Explain in terms of the path of the Sun and the daily period of daylight, the placement of your North Pole annual radiation curve.

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8. Compare all the annual radiation curves. What is the relationship between latitude and the annual range of solar radiation received?

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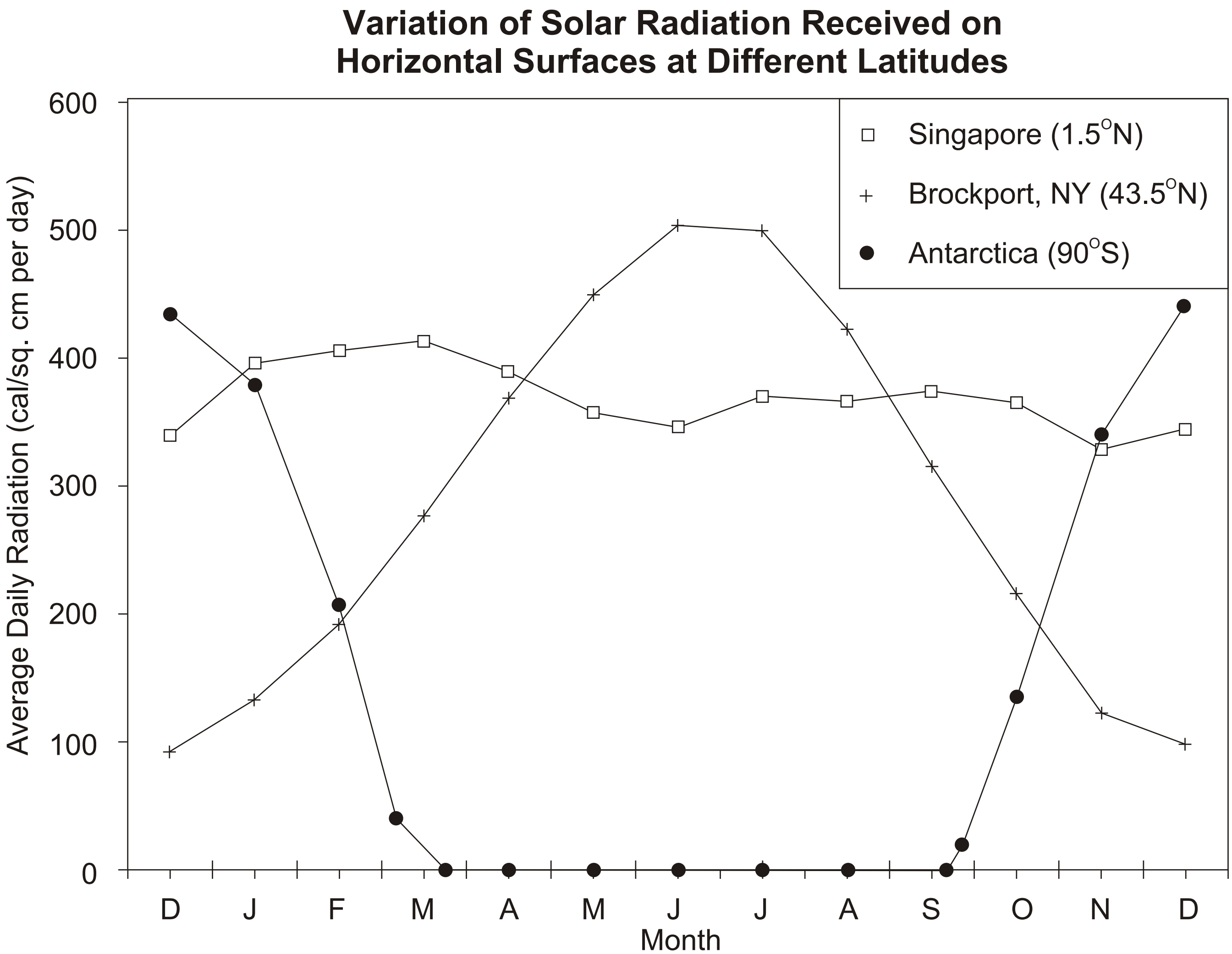
9. To mark the positions of the equinoxes and solstices, draw vertical lines on the graph at approximately March 21, June 21, September 23, and December 21. On the Equinoxes, the Sun is directly above the equator, while on the solstices the Sun is directly above 23.5 degrees North or South latitude. Label the intervals between the lines as the Northern Hemisphere's - Winter, Spring, Summer and Fall seasons.

10. The area enclosed under each curve between respective dates is directly proportional to the total energy received during that time period. At which location do all the seasons receive about the same total amount of solar radiation? ________________________________.

11. At the mid-latitude location, which season(s) receive the most solar energy? _____________________________. Which receive the least? ________________________________.

12. At the North Pole, which season(s) receive no solar radiation at all? ______________________.

13. Calculate the annual amount of solar radiation received at the three locations. The equatorial and mid-latitude locations receive how many times more solar energy than either pole? ________________________________.



Average Daily Solar Radiation per Month (cal/sw.cm/day)

	□	+	●	NP
Jan.	394	132	376	
Feb.	403	190	205	
Mar.	410	274	40	
Apr.	354	365	0	
May	386	446	0	
Jun.	342	500	0	
Jul.	365	495	0	
Aug.	361	418	0	
Sep.	368	310	18	
Oct.	359	210	129	
Nov.	323	117	333	
Dec.	337	92	433	