Acknowledgement: I (Larry Woolf) would like to thank Craig Bohren for his very helpful comments, suggestions, improvements, and corrections to the seasons poster.

Activities associated with Larry Woolf's seasons poster 2/16/04

Probing questions:

a. Why do we have seasons?
b. Describe your seasons? When do they occur? How do temperatures and daylight hours vary with the seasons?
c. What are the seasons like in the southern hemisphere (assuming you live in the northern hemisphere?
d. Why are temperatures warmer during the day and colder at night? (Point out that if the temperature is due just to the sun's heating, then the temperature should stay the same after the sun sets.)
e. Show how light rays travel from the sun to the earth.
f. Draw a picture of the earth's orbit around the sun.

Activities Associated with the Poster

1. Determine monthly average solar insolation levels for all 12 months for a city near where you live.

General web site on solar insolation and gateway to cities around the world:
http://www.apricus-energy.com/insolation.htm

Solar insolation data for New York City used in poster:
http://www.apricus-energy.com/insolation_levels_nth_am.htm

Solar insolation data for Wellington New Zealand used in poster:
http://www.apricus-energy.com/insolation_levels_asiap.htm

Other useful sites for solar insolation and related data:
http://rredc.nrel.gov/solar/old_data/nsrdb/redbook/sum2/
http://www.nrel.gov/gis/solar_maps.html
http://www.eere.energy.gov/consumerinfo/refbriefs/v138.html
http://visibleearth.nasa.gov/cgi-bin/viewrecord?7708
http://earthobservatory.nasa.gov/Newsroom/NewImages/Images/insolation.gif

For daily/hourly values for solar insolation data:
http://homer.ssec.wisc.edu/~insol/
http://rredc.nrel.gov/solar/pubs/NSRDB/background.html
http://www.geog.ouc.bc.ca/physgeog/contents/7l.html

2. Determine the number of daylight hours each month for a city near where you live.

http://www.timeanddate.com/worldclock/aboutastronomy.html
or
http://aa.usno.navy.mil/
then click on data services
Other daylight references:

Earth's Tilt and the seasons worksheet
http://www.materialworlds.com/sims/SolarSystem/worksheetSolsticeEquinox.html

3. Determine the distance from the sun to the earth for each month of the year.
Go to:
http://aa.usno.navy.mil
then click on:
Web Version of MICA
http://aa.usno.navy.mil/data/docs/WebMICA_2.html -
Multi-Year Interactive Computer Almanac
-includes positions, rise/set/transit, physical ephemerides - plus sidereal time & Julian dates
then click on
Topocentric Configuration of Major Solar System Objects
And then Continue
And then enter latitude and longitude of your desired city
And then click Compute and Display Data

Possible activity: Plot this data as an xy chart and as a "orbit" (polar) chart.

4. Investigate how earth-sun distances are determined.
http://curious.astro.cornell.edu/question.php?number=400

http://www.ncsec.org/cadre2/team24_2/earth-sun%20distance.htm

5. Determine the maximum angle of the sun above the horizon (altitude) for the first day of each month:
http://aa.usno.navy.mil/data/docs/AltAz.html

Definition of altitude:
http://aa.usno.navy.mil/data/docs/AltAz.html#Notes

6. Determine the average monthly temperature of your city:
Many resources including:
http://www.washingtonpost.com/wp-srv/weather/historical/historical.htm
http://www.immigrationvisa.org/Wellington.htm (for Wellington NZ)

7. a. Show how light is emitted from a single point source.
b. Show how light is emitted from two nearby point sources.

c. Show how light is emitted from a line source.
d. Show how light is emitted from a spherical source like the sun. Show how that light ends up at earth. In what direction is the light coming from?

8. Consider Earth if it was not tilted at all.
At what degree of latitude would the sun be overhead?
At what latitude would the sun be overhead if the earth's north pole was tilted at 5 degrees toward the sun?
At what latitude would the sun be overhead if the earth's north pole was tilted at 15 degrees toward the sun?
At what latitude would the sun be overhead if the earth's north pole was tilted at 23.5 degrees toward the sun?
At what latitude would the sun be overhead if the earth's north pole was tilted at 23.5 degrees away from the sun?

9. Consider Earth when its north pole is titled at 23.5 degrees toward the sun.
What is the maximum altitude of the sun at the equator (0 degrees latitude)?
What is the maximum altitude of the sun at 47 degrees north latitude?
What is the maximum altitude of the sun at 40 degrees north latitude?
What is the maximum altitude of the sun at 23.5 degrees south latitude?
What is the maximum altitude of the sun at 40 degrees south latitude?
What is the maximum and minimum altitude of the sun at noon for an entire year for someone who lives at 40 degrees north latitude?

10. What would the seasons be like if
a. the earth was not tilted at all?
b. the tilt was 10 degrees?
c. the tilt was 45 degrees?

11. What would the seasons be like if the earth was 100 times closer to the sun? 100 times farther from the sun?

Seasons References

1. A Private Universe
http://www.learner.org/teacherslab/pup/index.html

2. The Earth's Orbit
http://hea-www.harvard.edu/ECT/the_book/Chap2/Chapter2.html

3. The Real Reasons for the Seasons - Sun-Earth Connections for grades 6-8. A Lawrence Hall of Science GEMS unit.
http://www.lhsgems.org

4. "Mad Dogs and Englishmen Go Out in the Midday Sun," Chapter 10 in What Light Through Yonder Window Breaks by Craig F. Bohren, John Wiley and Sons, Inc., New York 1991.

5. Bad Astronomy
http://www.badastronomy.com/bad/misc/seasons.html

Bad Seasons
http://www.badastronomy.com/bad/misc/badseasons.html

6. Season Misconceptions:
Go to: http://www.sci-ed-ga.org/GASEFPresentations.html
Then click on:
"San Dieguito District Science In-Service Jan. 26, 2004: Seasons and Color Misconceptions" (Large file! 8MB)

6. To Every Season There is a Reason
http://www.astrosociety.org/education/publications/tnl/29/29.html

7. Season
http://scienceworld.wolfram.com/astronomy/Season.html

8. National Geographic
A Reason for the Season
http://www.nationalgeographic.com/xpeditions/activities/07/season.html

Seasons: Why It's Essential
http://www.nationalgeographic.com/xpeditions/lessons/07/g912/seasons.html

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Global Energy Balance References

1. Why Isn't Earth Hot as an Oven?
http://earthobservatory.nasa.gov/Library/Oven

2. Clouds and Radiation
http://earthobservatory.nasa.gov/Library/Clouds/

3. Data Sets
http://earthobservatory.nasa.gov/Observatory/datasets.html

4. Global Warming
http://earthobservatory.nasa.gov/Library/GlobalWarming/

5. Solar Radiation

http://rredc.nrel.gov/solar/pubs/shining/

6. Solar Radiation
http://edmall.gsfc.nasa.gov/inv99Project.Site/Pages/science-briefs/ed-stickler/ed-irradiance.html

7. Energy Balance and Temperature
http://homepages.wmich.edu/~cutrim/course/225/AguadoClassnotes/Chpt3/Aguadoch3.ppt

8. Earth's Energy Budget
http://asd-www.larc.nasa.gov/erbe/components2.gif

9. The Earth's Radiation Energy Balance
http://cimss.ssec.wisc.edu/wxwise/homerbe.html

Bad Seasons: Diagrams and terminology to avoid:

1. From: A Private Universe Teacher's Guide p. 18
"In the winter when the sun is lower in the sky, its light reaches the ground at a lower angle, spreading out it warming ability. This is the phenomenon sometimes referred to as "indirect rays.""

Avoid the term "indirect rays." Indirect can indicate to the student that the rays do not come directly from the sun.

2. From: A Private Universe Teacher's Guide p.18
"Also, the Earth's surface has more time to cool off at night in winter than in summer."

This implies that the earth cools by emitting infra red radiation only at night, when it cools by emission of infra red radiation at all times.

3. Avoid misleading diagrams that indicate that the sun only emits light in parallel lines out two sides of the sun, such as at:

http://hea-www.harvard.edu/ECT/the_book/Chap2/Chapter2.html

4. Avoid misleading diagrams that indicate that the sun is much closer to the earth in one season vs another and that the orbit looks highly elliptical, such as at:

http://www.cartage.org.lb/en/themes/Sciences/Astronomy/TheUniverse/Timekeepingandthecelestial/TheSeasons/TheSeasons.htm

or

http://www.uwm.edu/~kahl/CoVis/Seasons/

5. We should not confuse students with diagrams that show that the sunlight striking the earth consists of parallel rays, as the "why are there seasons" sites above show, and then show them that the rays are highly non-parallel, as when we discuss eclipses, as in the following sites:

http://www.earthview.com/tutorial/causes.htm

or

http://www.exploratorium.edu/eclipse/why.html

or

the diagram on page 4 of
"What is Light and How Do We Explain It by Bill Aldridge
Published by the Scope, Sequence, and Coordination High School Project
National Science Teachers Association
Published by the National Science Teachers Association, 1996
ISBN: 0-87355-154-0
NSTA Stock Number: PB135X

6. Avoid terms such as "the sun's rays are strong or weak" as at:
http://www.msnbc.com/news/251727.asp

"The situations are reversed in December, when it's the Southern Hemisphere that basks in the most direct rays of the sun, while the Northern Hemisphere receives the weakest rays."

Note that this site also states, incorrectly: "The sun's rays are weak because they … must travel through more energy-absorbing atmosphere to before reaching the earth." This incorrect statement is also included in the opening diagram of this article.