Lesson 2 - Data Exploration and Interpretation: Understanding the UV/Ozone Relationship

Summary:
Students will understand the relationship between stratospheric ozone and Ultraviolet radiation. They will model the Sun/Earth relationship, complete graphing exercises, and view real NASA data to better understand how humans can impact ozone concentration and effect Earth's climate.

Ozone in Earth's stratosphere affects how much ultraviolet radiation from the sun gets to Earth's surface. The following lesson will teach students about how Earth's seasonal ultraviolet radiation exposure changes seasonally by latitude. This concept will be further investigated in the context of the relationship of ozone and harmful ultraviolet radiation. Ozone limits harmful Ultraviolet exposure on Earth's surface.

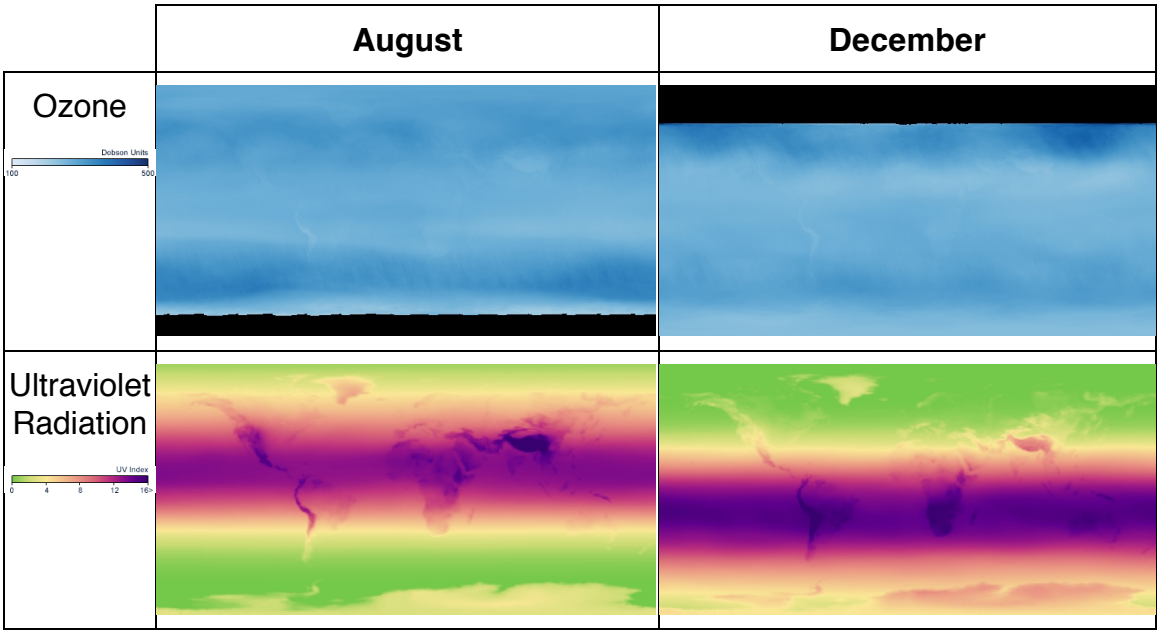


Image credit: Adapted from http://neo.nasa.gsfc.gov. In the images above the dark blue areas (high concentrations of ozone) in the ozone images correlate with the green areas in the lower images (areas of low ultraviolet radiation).

Time: 1 to 2 45-minute class periods

Science standards addressed:

MS-ESS2-1. Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process.

MS-ESS3-2. Analyze and interpret data on natural hazards to forecast future catastrophic events and inform, the development of technologies to mitigate their effects.

MS-ESS3-5. Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.

Engagement

Teacher should put on sunglasses (because wearing sunglasses inside is funny and easily gets students' attention) and hold up a bottle of sunscreen. Then, ask students "What do sunglasses and sunscreen protect us from?" Students should brainstorm ideas, while a student scribe or the teacher records student responses. Sample responses: the sun, the suns rays, light, etc.

Sunglasses protect us from ultraviolet radiation, UV rays, from the sun. If the type of sunscreen used as a prop mentions this on its label, students can be shown the bottle where it is mentioned.

Ask students, "What problems can UV rays cause?" Student scribe or the teacher can record students' ideas. Sample responses: sunburn, damage to crops, skin cancer, cataracts (eye damage), illness, etc. For reference and further information about the health hazards of UV exposure read https://www.epa.gov/sites/production/files/documents/healtheffects_1.pdf from the Environmental Protection Agency (EPA).

Exploration

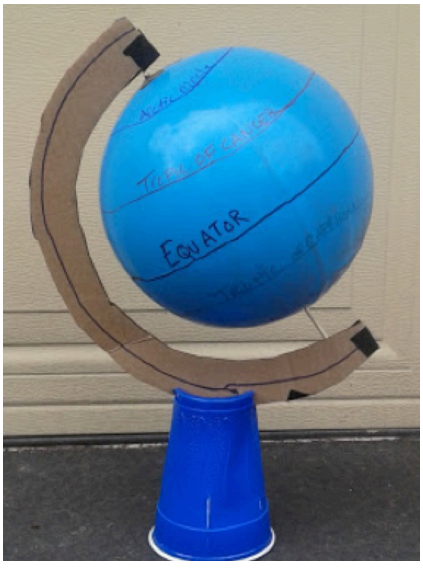
Create a model of the Earth and the sun or **use a classroom globe**.

Materials:

- Medium sized styrofoam ball
- Wooden skewer
- Cardboard
- Disposable cup
- Tape
- Lantern

Set up (See image to the right for completed Earth model):

1. Draw a line around the ball's center and label it "equator."
2. Draw a red line above the equator 1/3 the way between the "equator" and the of the ball and label the line "Tropic of Cancer."
3. Draw a line halfway between the "Tropic of Cancer" and the top of the ball and label it "Arctic Circle."
4. Draw a green line 1/3 the way between the "equator" and the bottom of the ball and label it the "Tropic of Capricorn."



5. Draw a line halfway between the “Tropic of Capricorn” and the bottom of the ball and label it “Antarctic Circle.”
6. Place a wooden skewer through the center of the ball.
7. Cut a large C-shaped piece of cardboard. The inside of the “C” should be larger than the outside of the ball.
8. Cut a slit in the bottom of the disposable cup and insert the C-shaped cardboard so the ends are at an angle as shown in the image below.
9. Attach the ends of the skewer to each end of the C-shaped piece of cardboard and secure with tape.

Activity:

1. Place the lantern in the middle of the room.
2. Assemble students into a large circle around the lantern. Explain that they are the “orbit” of the earth around the sun, represented by the lantern. They will be passing the earth around the orbit, observing where the sun is shining on the Earth.
3. Turn the lights off or down (the room should not be completely dark for safety reasons, but the lighting should be dimmed to help students see the effect of the light on the model of the earth)
4. Turn the lantern on.
5. The students should pass the earth model around the circle. Make sure that the C-shaped piece of cardboard consistently faces the same direction, to make sure that the tilt of the earth is being modeled correctly as the earth model travels around its “orbit.” See diagram below.
6. Give a winter hat or mittens to the person at the Winter solstice position, a fake flower to the person at the vernal equinox position, the sunglasses from earlier to the summer solstice position and an orange, red, or yellow leaf (or something else that is associated with Fall) to the person at the autumnal equinox position.

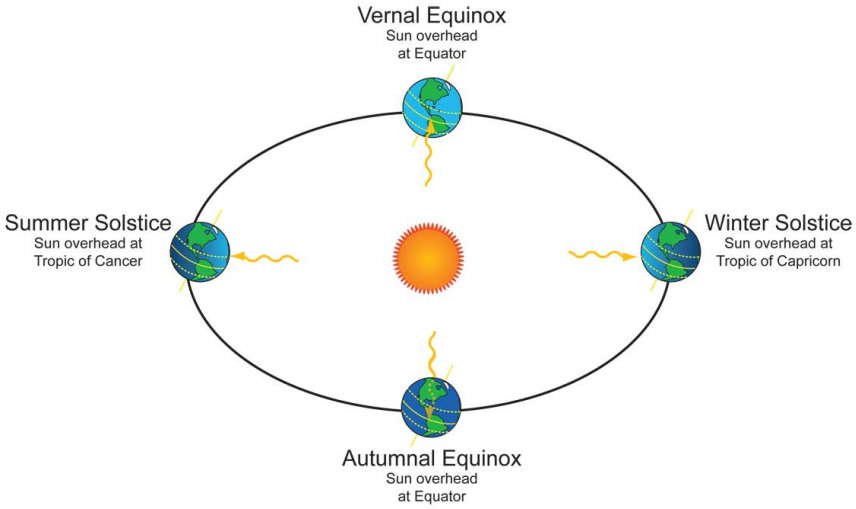


Image Credit: NASA Jet Propulsion Laboratory, from http://scijinks.jpl.nasa.gov/solstice/

Discussion:

As students pass the earth model around ask the following questions, generating a classroom wide discussion.

- Between what two lines on the earth model does most of the light from the lantern shine? (Between the tropics of Cancer and Capricorn over the Equator)
- Does the light change where it shines as the earth model moves through the orbit? (Yes. The light shines most directly at the tropic of Capricorn when it is held by the person wearing the winter hat or mittens. The light shines directly at the equator at both the autumnal and vernal equinox, when the person with the flower and autumn leaf are holding the earth model. The light shines most directly at the Tropic of Cancer when the person at the summer solstice –wearing sunglasses- is holding the earth model)
- Does UV exposure vary by season? (Yes, it would be greatest in the northern hemisphere's summer because the suns rays are most direct at the Northern Hemisphere during this time.)
- Does UV exposure vary by latitude? (Yes, but this is something we will explore in the following graphing exercise, which uses locations from a variety of latitudes throughout the globe)

How is Ozone related to UV radiation? Using real NASA data in exploration.

Hand out L2A Ozone vs. Latitude Graphing Assignment to half of the class and L2B UV Radiation vs. Latitude Graphing Assignment to the other half of the class and have them independently or in pairs complete the graphs. When they are complete have them discuss their results and answer the questions on the back of their graph with another student who completed the other assigned graph.

Teacher note: Cities on the table are at different latitudes and concentration of ozone are stratospheric ozone concentrations at 1) the Equator, 2) Midlatitudes, 3) Antarctica, 4) Arctic, 5) Australia

Questions students are asked:

- What happened to ozone concentrations as latitude changed (negative latitude values are in the southern hemisphere)?
- How are the two graphs related? What is the relationship between UV radiation and Ozone concentration?

Explanation

Explain the relationship between UV and ozone with a partner, record answer

As Ozone concentrations decrease, UV radiation increases. This means that more UV rays are reaching Earth's surface when ozone concentrations high in the atmosphere are reduced. In this way, ozone in the stratosphere acts like sunscreen, blocking harmful UV rays from reaching Earth's surface. This is reinforced in the following video.

Elaboration

Why are we talking about this? Why is ozone important? What have we heard about in the news?

- Show animation of NASA data from Aura that shows the ozone hole from July 2013 - December 2013 http://ozonewatch.gsfc.nasa.gov/education/ozone_movie.mp4.
- Brainstorm: Ask the students if they know what the dark blue and purple areas represent *(students brainstorm and come up with ozone hole).*

Evaluation

Watch *Big Ozone Holes Headed For Extinction By 2040* video clip. Video is available for download from the following link:

http://svs.gsfc.nasa.gov/cgi-bin/details.cgi?aid=11781 (2 minutes)

Ask students to consider what will happen to UV radiation as the Ozone hole shrinks. What happened to UV radiation as the ozone whole grew? Record their answers on the back of their graph worksheets in the space provided.

Then students should read the ChemMatters article from the American Chemical Society, available at the following link with a printable pdf. http://www.acs.org/content/acs/en/education/resources/highschool/chemmatters/past-issues/archive-2012-2013/ozone-layer-our-global-sunscreen.html. The article covers an experiment where ozone concentrations were changed to show what our Earth would be like if ozone depleting chemical use had never been reduced. After reading this article, students should write a journal entry about what Earth would be like if the ozone depleting chemicals had not been reduced. They can Title their entry, "The World Avoided."

Students should turn in completed graphs, explanations and journal entries for credit.

Extension:

For students seeking further information or for students who are interested in learning more or for advanced students, the following resources can be used to supplement the lesson and further explain the "World Avoided" experiment.

- A video representation of the data from the "World Avoided" experiment is available from the following link:
  - http://svs.gsfc.nasa.gov/cgi-bin/details.cgi?aid=4272
- A complete talk by Paul Newman, one of the lead scientists on the World Avoided experiment is available at the following link:
  - http://svs.gsfc.nasa.gov/cgi-bin/details.cgi?aid=11813
- Monitor the ozone hole http://ozonewatch.gsfc.nasa.gov/
- Monitor your daily UV index https://www.epa.gov/sunsafety/uv-index-1