MY NASA DATA Lesson:

Validation of Stratospheric Ozone

Purpose:

To provide an example case study of a validation of NASA satellite data with atmospheric sounding observations of atmospheric ozone levels using either graphing calculators or Microsoft Excel.

Note: the term graphing calculators for this lesson is in reference to Texas Instruments graphing calculators, specifically the TI-84 Silver Plus.
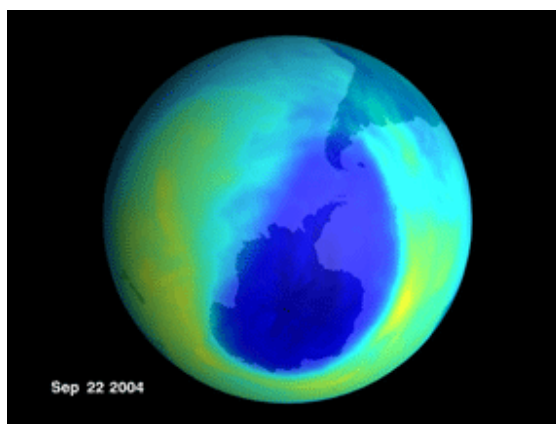

Image courtesy TOMS Science Team

Grade Level: 9-12

Estimated Time for Completing Activity:

50 Minutes

Learning Outcomes:

- Compare two methods of measuring stratospheric ozone
- Relate slope of a line to change in concentration of a gas
- Understand how ground data can be used to validate satellite data

Prerequisite

- Familiarity with importing data into a spreadsheet program or graphing calculator
- Familiarity with statistical analysis using a spreadsheet program or graphing calculator.

Tools

- Spreadsheet program
- Graphing calculator – lesson procedure uses the TI-84 Silver Plus

Vocabulary:

- chlorofluorocarbon
- number density
- ozone
- ozone layer
- ozonesonde
- SAGE III
- solar occultation
- stratosphere
- troposphere
- validation

Lesson Links:

- ESRL/GMD Ozonesondes

- Using Imported Data in Excel

- Current Ozone Updates

- Importing Data into Excel

- Directions for importing data into graphing calculator

- Graph of ozone profiles

- Microset

- Using linear regression functionality on graphing calculator
- Ozone hole versus normal profile

Background:

Over the past several decades, the levels of ozone in the atmosphere have received a lot of media and government attention. Major focus has centered on the hole or area of depletion of the ozone layer over the Arctic and Antarctic poles in winter months, which has been found to be due to human emissions of chlorofluorocarbons.

To better understand the complex interactions taking place in the atmosphere, scientists have designed satellites to take precise measurements of ozone and aerosols

in the stratosphere. These satellites use a technique called solar occultation to measure ozone in the upper atmosphere. In order for scientists to know if the satellite data are reliable, the data must undergo a process known as validation. Validation requires that data measured by other means be used in comparison with the satellite data. For ozone validation, ozonesonde data is used. An ozonesonde is a special type of weather balloon which carries an ozone sensor and is designed to take measurements into the stratosphere.

This lesson uses SAGE III satellite data and ozonesonde data captured over Thule, Greenland on October 26, 2002. Of major importance is how well the satellite compares to the ozonesonde data. The graph, accessed via the links section, shows how SAGE III corresponds to the ozonesonde data. For this lesson, only data from the stratosphere (above 20 km) are used.

Procedure:

Computer based:

1. Download the microset of stratospheric ozone profiles via the links section.

2. Import the data into a spreadsheet. For assistance with how to import the data and make a graph using MS Excel please refer to USING IMPORTED DATA IN EXCEL.

3. Graph the data (Hint: in order to get these data to graph correctly in Excel you may need to highlight JUST the numbers in the x (number density) and y (altitude) column from the ozonesonde. Then, at Step 2 of the Chart Wizard, click on Series to Add the SAGE III data).

4. Use MS Excel's Add Trendline function to give a linear equation for both graphs. (Hint: it may be helpful to divide the number density by 1.e12 to get more significant digits on the trendline.)

Graphing calculator based:

1. Download the microset of stratospheric ozone profiles via the links section. Then choose either dataset to work with first.

2. Import the data into the graphing calculator. For step-by-step instruction on importing the dataset into the graphing calculator refer to DIRECTIONS FOR IMPORTING DATA INTO THE GRAPHING CALCULATOR.

Modification: subset the data and let the students input the data into the calculator manually until all the data points are in the calculator's List function.

3. Use the calculator's Linear Regression function to find the equation of the line that best fits the graph. Be sure to write down the equation for the graph. For step-by-step

instruction on using this functionality refer to USING THE LINEAR REGRESSION FUNCTIONALITY ON A GRAPHING CALCULATOR.

4. Repeat steps 1-4 for the other dataset.

Questions:

1. In the stratosphere, is the slope positive or negative? What does the positive or negative slope say about the ozone concentrations?

2. You wrote down each graph's linear regression for the stratosphere. This linear regression provides the coefficients (a and b) of a straight line which approximates the data. Looking at the slope coefficients (a) of each graph, do you think that the slopes are close to each other? What does that mean? What can you infer about the actual data?

3. In comparing the graphs, do you think that the satellite does a good job of capturing the data that the ozonesonde captures? Are the graphs similar or dissimilar? Do you think the satellite provides accurate data?

4. Looking at the 'graphs of ozone profiles' which contain information down to 7 km, what is happening to the concentration of ozone in the troposphere? In the stratosphere?

5. Refer to the link for 'Ozone hole versus normal profile'. How does the profile of ozone in the stratosphere change during a large ozone hole event?

Extensions:

1. What would happen if the Earth didn't have the ozone layer? How would life as you know it change? Plants, animals, humans, water.

2. What will happen if the hole in the ozone over the Arctic and Antarctic continues to grow? What would happen if a hole appeared over where you live?

3. If you went to another planet that didn't have an ozone layer, what do you think could be done to protect yourself? What types of things would have to be developed?

4. Ambitious students may wish to explore the available ozonesonde data from the ftp site in the links section.

Lesson plan contributed by Erica Alston, NASA

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