Experiment 4:

Measuring Atmospheric Ozone from Satellite

Difficulty: Moderate to Advanced

Background

The ozone layer protects the Earth from harmful ultraviolet (UV) Sun rays, similar to the way sunscreen protects humans from sunburns. Prior to 1978, consumer aerosol products used chlorofluorocarbons (CFCs) as aerosol propellants. Since CFCs negatively react with the Earth's upper ozone layer by reducing its ability to absorb the Sun's UV radiation, scientists and environmentalists were concerned that use of aerosol products use might result in an increase in UV rays reaching lower levels of the Earth's atmosphere. Consequently, the Environmental Protection Agency (EPA) banned the use of CFC propellants in 1978.

Scientists using satellites can determine the presence and the amount of ozone in the atmosphere by measuring the amount of UV radiation being absorbed by the atmosphere. They, then, calculate how much ozone must be present in order to absorb that amount of UV radiation. Satellite data is essentially the same as that recorded from ground instruments, but it views the measurements from outer space, collected from above the ozone layer. Ozone presence is typically measured in Dobson units (DU), with one Dobson unit equivalent to a 0.1 mm layer of ozone (at 0^0C and 1 atmosphere of pressure); this represents how thick the ozone layer would be if it were located at the Earth's surface at 32^0F.

Measurements are from a variety of satellites, each recording specific data from a specific location and for a specified time period. Satellite data may be publicly available online from the various agencies that manage the satellites. For example:

- NOAA Satellite Information Service; National Environmental Satellite Data and Information (NESDIS): www.nesdis.noaa.gov/.
- Space Science and Engineering Center, University of Wisconsin-Madison: www.SSEC.wisc.edu/data/.
- NASA's Global Hydrology and Climate Center: www.ghcc.msfc.nasa.gov/GOES/.

Learning Goals

1. The student will learn how scientists and environmentalists measure atmospheric ozone from satellites.
2. The student will learn the role atmospheric ozone plays in affecting weather.
3. The student will learn to use relevant data to determine what factors may impact changes in the ozone layer.

Materials

- Computer with Internet access
- Graphing materials or graphing software

Procedure

1. Using the NASA website, http://gsfc.nasa.gov/, or another Internet website, find the satellite data for the Total Ozone Mapping Spectrometer (TOMS) program.
2. Determine which of these NASA satellites were in use during the desired time period:

NIMBUS-7	**METEOR-3**
Earth Probe	**OMI/Aura**

EXAMPLE:

What was the ozone reading above Chicago, IL on Jan 1st, 1979?

[NOTE: Make sure you use data from the correct satellite, knowing the date of operation; in this case, it would be the NIMBUS-7 satellite]

3. Go to the TOMS homepage and search for Nimbus-7 data.

4. Click on the "Ozone over Selected Locations" link.

5. Scroll to "Chicago, IL" and select it.

6. Scroll down date data to Day 001 of 1979 (which would be Jan 1st of 1979, etc.).

7. Follow the table row to the column headed "OZONE", measured in Dobson units.

8. Other dates or cities can be selected in the same manner.

ANS: The ozone reading above Chicago on 1/1/79 was 321.7 DU

Discussion

1. *How does the daily ozone profile compare with daily weather?* The student might track ozone level (Dobson units, parts-per-million, etc.) and compare it to the daily high temperature to see if there is a correlation (i.e. Does high ozone level cause higher-than-average temperature? Or, might it result from the higher-than-normal temperatures?).

2. *Does the daily ozone profile compare with seasonal changes?* The student might track the ozone level seasonally and see if there appears to be regular seasonal changes.

3. *Does a catastrophic event (such as volcanic eruption, earthquake, hurricane, etc.) seem to have any effect on the atmospheric ozone level?* The student might check the archives to see if data collected shortly after such an event might produce a noticeable impact on the ozone level.

4. *Does the satellite-measured atmospheric ozone level correlate to that measured from ground-level?* What might cause any differences?

5. *Does the atmospheric ozone level measured from satellite seem to change in industrial areas after the CFC ban in 1978?* (Remember such an impact might not be instantaneous).