Surface Ozone Measurement Protocol

Purpose:

- To define the S.M.O.G. team procedures for measuring ozone concentrations at ground level using photochemical reaction strips.

Educational Outcomes:

- Understanding of how to accurately record scientific data
- Appropriate data representation and analysis
- Understanding cause and effect (observe and explain reactions)
- Interconnection of atmospheric conditions
- Identifying patterns in surface ozone production

Overview:

- Students deploy a strip of paper, and returns one hour later to see how its' color has changed.

Time Required:

- Two five minute time periods, one hour apart

Grade Level:

- All

Frequency:

- Daily
- Start measurements within one hour of local solar noon

Key Concepts:

- Ozone exists in the air we breathe

Skills:

- Using a chemical strip to measure surface ozone
- Recording, graphing and analyzing data
- Sampling procedure
- Reading and recording ozone data
- Observing and recording atmospheric conditions

Materials and Tools

- Surface Ozone Investigation Data Work Sheet
- Clipboard
- Pencil or pen
- Surface Ozone hand-held scanner
- Chemical test strip in plastic bag
- Device to measure wind direction
- GLOBE Weather Box: If you do not have a weather box, you may use the current temperature from your automated weather station.

Prerequisites:

- Cloud Cover Protocol
- Maximum, Minimum and Current Temperature Protocol
- Measuring Wind Direction Instructions

Preparation:

- Assemble and install Ozone Monitoring Station
- Assemble or obtain installed Wind Direction Instrument

Teacher Support

Background:

There are many gases in the air, which are present in small amounts. Most of these trace gases are highly reactive chemicals and play a role in the complex chemistry, which determines the quality of the air we breathe. Sunlight, including the small amounts of ultraviolet light, that reaches Earth's surface, drives much of this chemistry. Sources of hydrocarbons, carbon monoxide, oxides of nitrogen, and other compounds also play a key role in this chemistry. The result is that the amounts of these trace gases vary with time of day, from day to day, and from place to place.

Ozone is often one of the more abundant trace gases. It is plays an important role in much of the chemistry of the atmosphere, and GLOBE students using simple chemical test strips can measure it. Ozone also reacts with surfaces, including living tissue exposed to the air. This makes the amount of ozone a key measure of air quality.

The Measurement:

The surface ozone measurement instrument is a chemically sensitive strip that changes color in the presence of ozone. The more ozone present, the more change you will see in the color. Surface ozone is the primary component of photochemical smog and usually peaks in the afternoon. The chemical strip is placed in the clip of the monitoring station within one-hour solar noon and left exposed to the air for one hour.

Placing the Chemical Strip:

A chemical strip is placed in ambient air or exposed to outside air that is moving freely around the monitoring station. It is important to keep the strip in a closed plastic bag or pouch until it is placed in the monitoring station. When preparing to place the strip, avoid touching the chemical on the strip to prevent contaminating it. However there is no danger should someone touch the strip. The chemical strip remains exposed to ambient air for one hour.

Record the cloud cover and type, current temperature, and wind direction after placing the chemical strip in the monitoring station.

Reading the Chemical Response:

Reading of the chemically sensitive strip may be completed in the field in total shade or in the classroom. The scanner must be calibrated in the environment where the reading of the strip will occur. To do this carry the scanner to the measurement site and place the scanner on a flat surface. Place an unexposed chemical strip with the chemical side (i.e. blank side) facing into

the scanner. The scanner will record and use the reflective properties of the unexposed strip to determine the ozone concentration of the exposed strip. The next task will be to remove the unexposed strip and insert the exposed strip with the chemical side facing into the scanner. For measurements on the exposed and unexposed strip, allow it time for the scanner to reach a stable reading (e.g. approximately 15-30 seconds). The team collecting the information records the level of response on the Surface Ozone Data Worksheet.

As soon as the concentration of surface ozone is recorded, students determine the type and amount of cloud cover, get the current temperature from the GLOBE maximum/minimum thermometer mounted in the instrument shelter, and record the current wind direction. These data can be compared to data collected from other schools in different geographic regions.

As young researchers learning about the air they breathe, they will explore how weather conditions can help produce ozone they breathe at the surface. It will be an opportunity to compare the data they gather with students from other regions of the world and create graphic summaries of their findings to analyze and summarize.

Determining the Concentration of Surface Ozone:

It is important to calibrate the ozone hand held scanner in the environment that you are taking the ozone reading, and to place the scanner on a flat surface with no movement. Use the blank side of an unexposed chemical strip to calibrate the scanner. Place the untreated side facing into the main part of the scanner. It will reflect 2-3 numbers as it reads the reflective properties of the white paper. Press both buttons to save the calibration.

Place the chemical strip into the thin slot with the chemical side facing toward the body of the scanner. Hold the edge of the chemical strip on the end with the words “Test Card”. Gently slide the strip into the slot on top of the scanner until the bottom of the strip touches the base of the scanner and won’t slide in any further. This places the circle with the chemical into the center of the end of the scanner. It will take a few seconds for the scanner to read the level of ozone, and identify and project the level of ozone in ppb.

Measurement Logistics:

The need to expose the ozone strip for one hour may pose a logistical challenge. One approach to solve this is to expose the ozone strip at the same time (i.e. within one hour of local solar noon) that the daily atmosphere measurements (i.e. maximum, minimum, and current temperature, precipitation, cloud cover and type) are made. These measurements will then provide the cloud and current temperature measurements needed to support the ozone measurement. Students would also read wind direction at this time.

Just a few minutes before an hour has passed students need to return to the site to measure the amount of ozone detected by the strip. At the same time, they will need to open the instrument shelter and read the current temperature, do the cloud cover and cloud type protocols, and again observe the wind direction. Unusual weather conditions (e.g. precipitation) that may have affected the response of the strip are reported as comments or metadata. The students who read the ozone strip do not have to be the same students who exposed the strip. This gives you some flexibility to work within the constraints of the school day and student schedules.

The key to this two time measurement is to establish a clear schedule so that everyone involves knows what they are expected to do and when to do it. Design a system so students know when the hour is nearly finished, and return to the site to read and record the data.

Ozone concentrations often vary over the day. To build a consistent set of ozone readings that can be compared across many schools, the primary data set desired is of measurements for a

one hour period that begins within one hour of local solar noon. This saves effort because the beginning measurements are mostly satisfied by collecting data for other protocols. If this timing will not work at your school or if you wish to take more ozone data, you may do this protocol at other times of day. These data may not be displayed on the visualizations of mid-day ozone values, but they will be included in the tables of data associated with your school and will be made available in graphs. The key is that the ozone strip is exposed for one hour and that clouds, current temperature, and wind direction are reported at both the beginning and end of this time period.

Placing the Ozone Monitoring Station:

The monitoring station is mounted on a permanent post and located in an open area to allow air to flow freely around the chemical strip. It should be located near the GLOBE Instrument Shelter to enable students to collect current required temperature data. Thus, the Ozone Monitoring Station is usually part of the Atmosphere Study Site.

The unit that holds the chemical strip should be attached to a 5-cm diameter by x 2.4-meter long wooden pole. Once the pole is permanently placed 60 cm into the ground, the monitoring station will be at 1.5 meters above ground placing the chemical strip at 1.3 meters above the ground. This will place the paper clip that holds the ozone sensitive strip at a good height for middle grade students. The pole may be shorter to locate the monitoring station at a convenient level for younger students or they can stand on the same step stool used to put their eyes level with the maximum/minimum thermometer in the instrument shelter. The plastic disk protects the chemically sensitive strip from light rain or snow.

The ozone monitoring station should conform to the specifications given in the Toolkit and may be constructed using the plan given there.

Student Preparation:

Students will need to be trained in the process of measuring and recording the surface ozone level. It will be important to the accuracy of the measurement that students are able to:

1. Work in cooperative groups of 3-4 students to gather, analyze, and discuss results.
2. Organize all materials needed to set up and take the measurement of surface ozone.
3. Determine local solar noon
4. Carry the chemically sensitive strip to the monitoring site in a plastic bag to control exposure time.
5. Identify and record the starting time when the chemical strip is placed in ambient air. The starting time must fall within the hour of solar noon.
6. Place the chemical strip in the clip being careful to avoid touching and contaminating the chemical on the strip.
7. Read the chemical strip at the end of one hour. The time the chemical strip is read will be after solar noon. This is okay.
8. Design a system to remember when the hour is nearly finished, and return to the site to read and record the response of the chemical strip as well as the time and required atmospheric data or unusual weather conditions that may have affected the response of the strip. This information is reported as comments or metadata.
9. Read the maximum/minimum thermometer and identify and record the current temperature <u>after</u> recording the measurement of surface ozone.

10. Identify and record cloud type and cover using the GLOBE cloud protocol.

11. Record data accurately and completely for future graphing and analysis.

12. Respond in their GLOBE Science Notebooks to a question that reveals the individual nature of their learning experience, share their responses with their team, discuss, and choose to add to their response as a result of their discussion without changing their original response.

Student Support:

Scientific Justification: The gases in the atmosphere vary from place to place and change during the day and from day to day. Changes in these gases alter the quality of the air we breathe. By monitoring the different gases, scientists can determine how the atmosphere is changing. Ozone is one of these gases. It varies significantly and reacts with many other gases and with the surfaces of living things that come in contact with it. This makes it particularly important for understanding air quality.

Collecting surface ozone data by the various S.M.O.G. teams will provide a record of the amount of ground level ozone found in different geographic regions, and the weather conditions that influence the amount of ozone in the air. This base of data over a period of time will contribute valuable information toward understanding how Earth's atmosphere may be changing near Earth's surface.

Synthesis Questions:

- Why do you think it might be important to learn more about the atmosphere?
- Is the amount of ozone you observe related to other atmosphere phenomena? Which ones? How?
- How can you use your data collected over a period of time to predict future changes in the atmosphere?

Distribute Student Protocol:

The Surface Ozone Measurements Protocol and the Student Ozone Protocol supports the first learning activity [Ozone in the Schoolyard] and is designed to integrate the surface ozone measurement into the classroom curriculum.

Data Collection (Helpful Hints):

- Set a timer or design a procedure to identify the hour the chemical strip is exposed to ambient air. It is important that the response of the chemical strip be read within the hour and not be over or underexposed.

- Have a designated area to keep the clipboard with the data worksheet to facilitate different teams working to record data. Keep the data worksheets in a notebook so that they are not misplaced

- From time to time check the detail of the data collecting to ensure that it is complete and accurate.