Surface Ozone Protocol

Draft 8/31/00

Surface Ozone Protocol

Purpose

To measure ozone concentrations at ground level

Educational Outcomes

Reading and recording data accurately

Appropriate data representation and analysis

Understanding cause and effect (observe and explain reactions)

Interconnection of atmospheric conditions

Identifying patterns in surface ozone

Overview

Students deploy a strip of paper which changes color in the presence of ozone and come back one hour later to measure how much its color has changed.

Time

Two five-minute time periods, one hour apart

Level

All

Frequency

Daily
Measurements starting within one hour of local solar noon are preferred.

Key Concepts

Ozone exists in the air we breathe.
The air around us can vary depending on where it has been.

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

Ozone Data Work Sheet
Clipboard
Pencil or pen
Chemical test strip in plastic bag
Ozone Test Strip Scanner
Device to measure wind direction

Preparation

Assemble and install Ozone Monitoring Station.

Assemble or obtain and install Wind Direction Instrument.

Prerequisites

Cloud Protocols

Maximum, Minimum and Current Temperature Protocol

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 amount 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 it can be measured by GLOBE students using simple chemical test strips. 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 GLOBE surface ozone measurement is taken using a chemically sensitive strip that changes color in the presence of ozone. The more ozone present, the more change that will occur. The chemical strip is placed in the clip of the monitoring station preferably within one hour of local solar noon and left exposed to the air for one hour. It is then read using a scanner. This scanner permits the strip to be read more accurately and precisely which enhances the scientific value of these data.

The amount of color change will also increase if the strip is exposed to ozone for a longer period of time. To ensure that GLOBE data are comparable around the world, the protocol specifies that the strip be exposed for only one hour and that the time it is exposed and the time it is read are reported to GLOBE to the nearest minute.

Placing the Chemical Strip

The chemical strip is 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 because once the strip is exposed it begins to react with any ozone that is present. When placing the strip, avoid touching the chemical on the strip to prevent contamination; however there is no danger should someone touch the strip.

Reading the Chemical Response

Reading of the chemically sensitive strip must be completed in the field. The team collecting the information records the level of response on the *Surface Ozone Data Work Sheet*.

Determining the Level of Surface Ozone

The hand held scanner provides a more sensitive reading of the color of the ozone test strip that can be achieved with the naked eye. The scanner is designed to give a reading of ozone concentration in units of parts per billion. The correspondence between the color of the strip and the average concentration of ozone in the air during the time the strip was exposed assumes that the exposure was for just one hour.

It is important to read the hand held scanner in a shaded area with the scanner placed on a stable surface. Sunlight and motion can affect the scanner reading. Place the chemical strip into the thin slot on top of the scanner. Hold the edge of the chemical strip on the end with the words "Test Card". The chemical side of the strip should face the display. 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 in 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 the ozone concentration in parts per billion.

Supporting Measurements

Since the chemistry of trace gases in the atmosphere depends on the amount of sunlight present, students are asked to record the cloud cover and type when they expose the strip and when they read it. Many chemical reactions also depend on temperature and so students are asked to measure current temperature when the strip is exposed and read. Lastly, the amounts of trace gases present may vary considerably depending on what is upwind from your measurement site. Students also measure the wind direction at the beginning and end of the exposure period.

In all cases the measurement of clouds, current temperature, and wind direction should be taken after placing the chemical strip in the monitoring station and after the strip is read.

These supporting data can be compared to data collected from other schools in different locations. As students learn about the air they breathe, they should explore how weather conditions can affect the amount of ozone in the air around them. Comparing the data they gather with students from other regions of the world is an appropriate topic for student inquiry.

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 that the daily atmosphere measurements of maximum, minimum, and current temperature, precipitation, and clouds are made within one hour of local solar noon. These measurements will then provide one set of the cloud and current temperature measurements required 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 go 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 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 involved 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 should require the least effort as noted above. If this timing will not work at your school or if you wish to take more than one ozone measurement a day, you may do this protocol at other times. 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 for both the beginning and end of this time period.

Student Preparation

Students need to be trained how to measure and record 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 2-4 students to gather, analyze, and discuss results.
2. Organize all materials needed to set up and take the measurement of surface ozone.
3. Identify and record the starting time when they expose the chemical strip, and accurately read the strip at the end of one hour.
4. Carry the chemically sensitive strip to the monitoring site in a plastic bag to control exposure time.

5. Place the chemical strip in the clip being careful to avoid touching and contaminating the chemical on the strip.
6. Read the current temperature from the maximum/minimum thermometer without altering the maximum and minimum settings.
7. Identify and record cloud type and cover using the GLOBE *Cloud Cover Protocols*.
8. Record data accurately and completely for reporting to GLOBE and for future graphing and analysis.
9. Record their observations in their individual GLOBE Science Logs.
10. Respond in their GLOBE Science Logs 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.

Tie to Learning Activity

The *Exposing the Ozone Test Strip* and *Reading the Ozone Test Strip Student Field Guides* support the *Ozone in the Schoolyard Learning Activity* designed to integrate the surface ozone measurement into the classroom curriculum.

Helpful Hints

Have a designated area to keep the clipboard with the *Data Work Sheet* to facilitate different teams working to record data. Keep the *Data Work Sheets* in a notebook so that they are not misplaced.

From time to time check the written record in the data notebook to ensure that it is complete and accurate.

Sometimes a chemical strip gets damaged while exposed to ambient air. If the chemical strip gets moist, the response will be marbled. Simply do not report data for this day or time period.

If there is no response on the chemical strip, enter 0 to indicate no surface ozone is present.

Student Support

Scientific Justification

Many gases in the atmosphere vary from place to place. Their abundance changes during the day and from day to day. These changes alter the quality of the air we breathe. Monitoring the amounts of these gases is important for our understanding of air quality and how it is changing.

Ozone is one of the most important of these gases. It varies significantly and reacts with many other chemicals in the air. It also reacts with the surfaces of living and non-living things that come in contact with it. This makes it an important part of air quality.

Collecting surface ozone data will provide a record of the amount of ground level ozone found in different geographic regions. These data will help scientists understand how weather conditions influence the amount of ozone in the air. This database will contribute valuable information for understanding how Earth's atmosphere may be changing.

Synthesis Questions

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?

Exposing the Ozone Test Strip
Student Field Guide

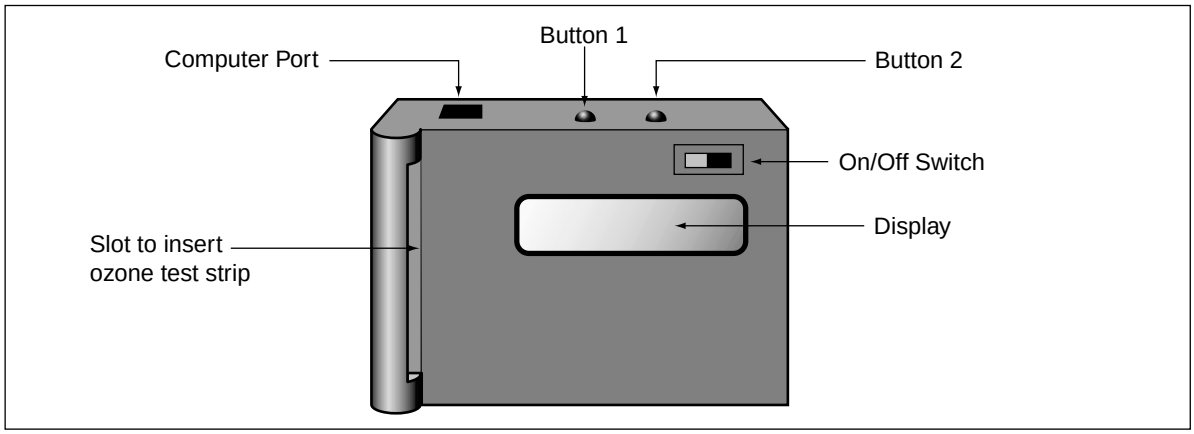
Task

Begin the measurement of surface ozone concentration.

Record cloud conditions, wind direction, and current atmosphere temperature.

What You Need

- ❑ One Ozone Test Strip
- ❑ Plastic bag to carry the measuring strip to your site
- ❑ Ozone Test Strip Scanner
- ❑ Clipboard
- ❑ *Surface Ozone Data Work Sheet*
- ❑ Pen or pencil
- ❑ GLOBE Cloud Chart
- ❑ *Cloud Cover Student Field Guide*
- ❑ *Cloud Type Student Field Guide*
- ❑ Wind Direction Instrument
- ❑ Key to your instrument shelter
- ❑ A clock or watch accurate to the nearest minute



In the Field

1. Fill out the top of the *Ozone Data Work Sheet.*

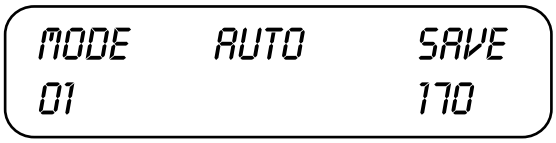
2. Remove a single ozone test strip from the plastic bag,

3. Record the date and starting time.

Calibrating the Scanner

4. Place the scanner on a steady surface out of direct sunlight.

5. Turn on the scanner and you should see the following in the LCD readout. (The number you see under SAVE may be different.)



6. Place the ozone test strip into the scanner with the **chemical side facing toward the display.**

7. Press button 1 until you see CALIB on the display.

8. Press button 2 to select CALIB.

9. Wait until the number under SAVE stops changing.

10. Hold down buttons 1 and 2 simultaneously to save the calibration. The scanner will return to Mode 01. (The reading under SAVE should read 000 and may fluctuate to 001. If it reads higher than 001, repeat steps 7 – 9 to recalibrate the instrument.

11. Remove the unexposed strip. Turn off the scanner.

12. Place this ozone test strip in the clip on the monitoring station. Do not touch the chemical part of the strip at any time. (It is not harmful to you, but touching it may prevent you from getting an accurate measurement.)

13. Determine cloud cover and cloud type following the *Cloud Cover and Cloud Type Protocols.*

14. Measure and record the current temperature on the thermometer in your instrument shelter (to the nearest 0.5° C).

15. Record the wind direction.

Reading the Ozone Test Strip
Student Field Guide

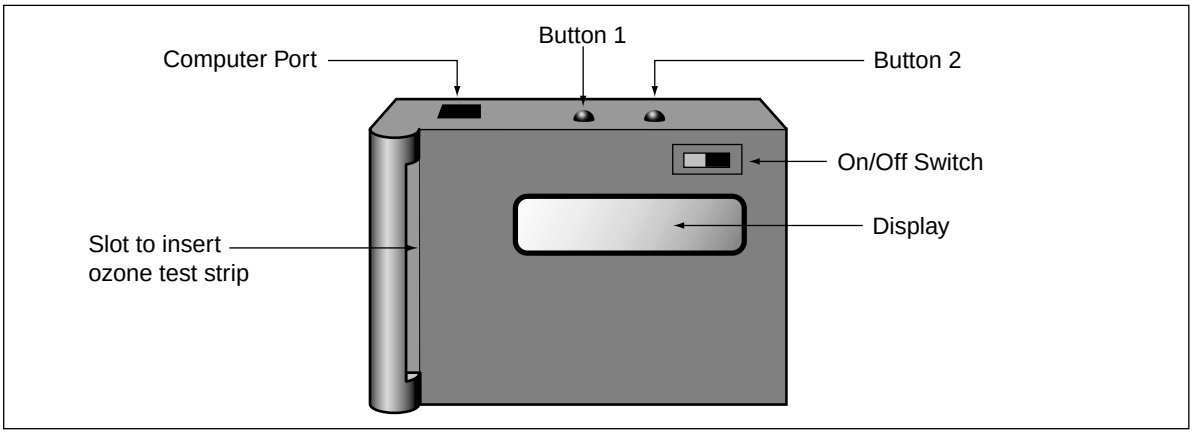
Task

Complete the measurement of surface ozone concentration after the ozone test strip has been exposed for one hour.

Record cloud conditions, wind direction, and current atmosphere temperature.

What You Need

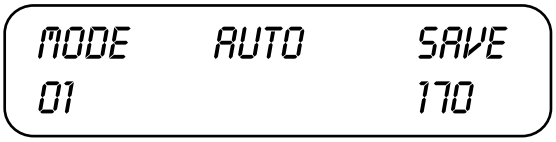
- ❑ Surface Ozone Color Chart
- ❑ Ozone Test Strip Scanner
- ❑ Clipboard
- ❑ *Surface Ozone Data Work Sheet*
- ❑ Pen or pencil
- ❑ GLOBE Cloud Chart
- ❑ *Cloud Cover Student Field Guide*
- ❑ *Cloud Type Student Field Guide*
- ❑ Wind Direction Instrument
- ❑ Key to your instrument shelter
- ❑ A clock or watch accurate to the nearest minute



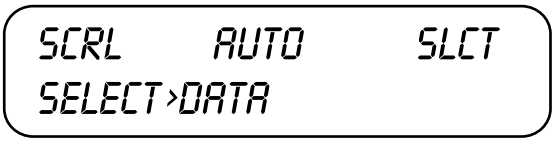
In the Field

After the ozone strip has been exposed for about one hour:

1. Turn on the scanner. You should see something like the following on the display.



2. Press Button 1 until you see the following on the display.



3. Press button 2 until you see DATA = OZONE on the display. Press button 1.
4. Press button 2 until you see MEASUREMENT = PPB. Press button 1.
5. Press button 2 until you see DURATION = 1 HR.
6. Press button 1 until you see MODE 01 again.
7. Remove the ozone test strip from the clip; be careful not to touch the chemical part of the strip.
8. Slide the strip into the scanner, with the circle end first, until the edge of the paper is even with the open slit on the bottom of the scanner. The chemical part of the strip should face the display.
9. Put one finger over the computer port on the scanner to block any outside light from entering the scanner.
10. Place the scanner on a stable surface out of direct sunlight and wait until the reading stops fluctuating.
11. Record the ppb reading on your Data Sheet.
12. Record the time you read the ozone strip.
13. Determine the cloud cover and cloud type following the *Cloud Cover and Cloud Type Protocols.*
14. Read the current temperature on the thermometer in your instrument shelter.
15. Record the wind direction.

Measure Wind Direction

Student Field Guide

Task

Determine wind direction using Wind Direction Instrument.

What You Need

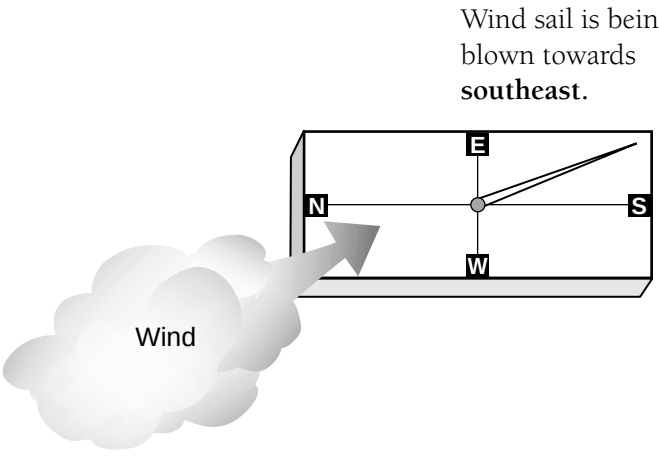
- ❑ Wind Direction Instrument
- ❑ *Ozone Data Work Sheet*
- ❑ Clipboard

In the Field

1. Place your wind direction instrument on a table or bench so that it is about 1 meter off the ground.
2. Orient the compass to read north and align the base of your model marked N to match north.
3. Look at the wind sail to see if there is any wind blowing.
4. Put your right hand on your hip and your left arm out straight.
5. Turn your body so that your straight arm is pointing in the same direction as the wind sail. Your right elbow is now pointing in the direction of the wind.
6. Record this direction on your data work sheet.

For example, if your wind sail is pointing south, your straight arm should be pointing south. In order for the wind sail to be pointing south, where does the wind have to be coming from? North.

Your straight arm is pointing where the wind is going, and you're the elbow of your bent arm is pointing in the direction where the wind is coming from, north. Winds are identified by the direction from which they are coming.



Frequently Asked Questions

1. What if the ozone strip doesn't have any color change after one hour?
If there is no color change, enter 0 on the data sheet, because it indicates that there is very little or no surface ozone present.

2. What if the ozone strip got wet due to rain or snow and the color is marbled, or the surface is not one complete color?
Your ozone measurement strip is contaminated or spoiled which means the data are not accurate. Report your data as M to the GLOBE Data Server. Note as a comment weather conditions which may have affected your results. Still measure the current temperature, cloud cover and cloud type and report them.

3. We are not in school on the weekend, how can we collect data?
Persistence in data collection is important, so work with your GLOBE team to arrange for a volunteer to bring one or two students to your Atmosphere Study Site on weekends and holidays if possible. Data from school days alone are still valuable, but for some schools weekends will have systematically different ozone levels.

4. Can the plastic disk and strip be placed on the weather station?
No. They would interfere with the rain gauge and should be on a different post.

5. Why is it important to take the temperature reading after recording the ozone level?
The strip will continue to respond to the gases in the air. So it is important to take the ozone reading and then the temperature reading.