

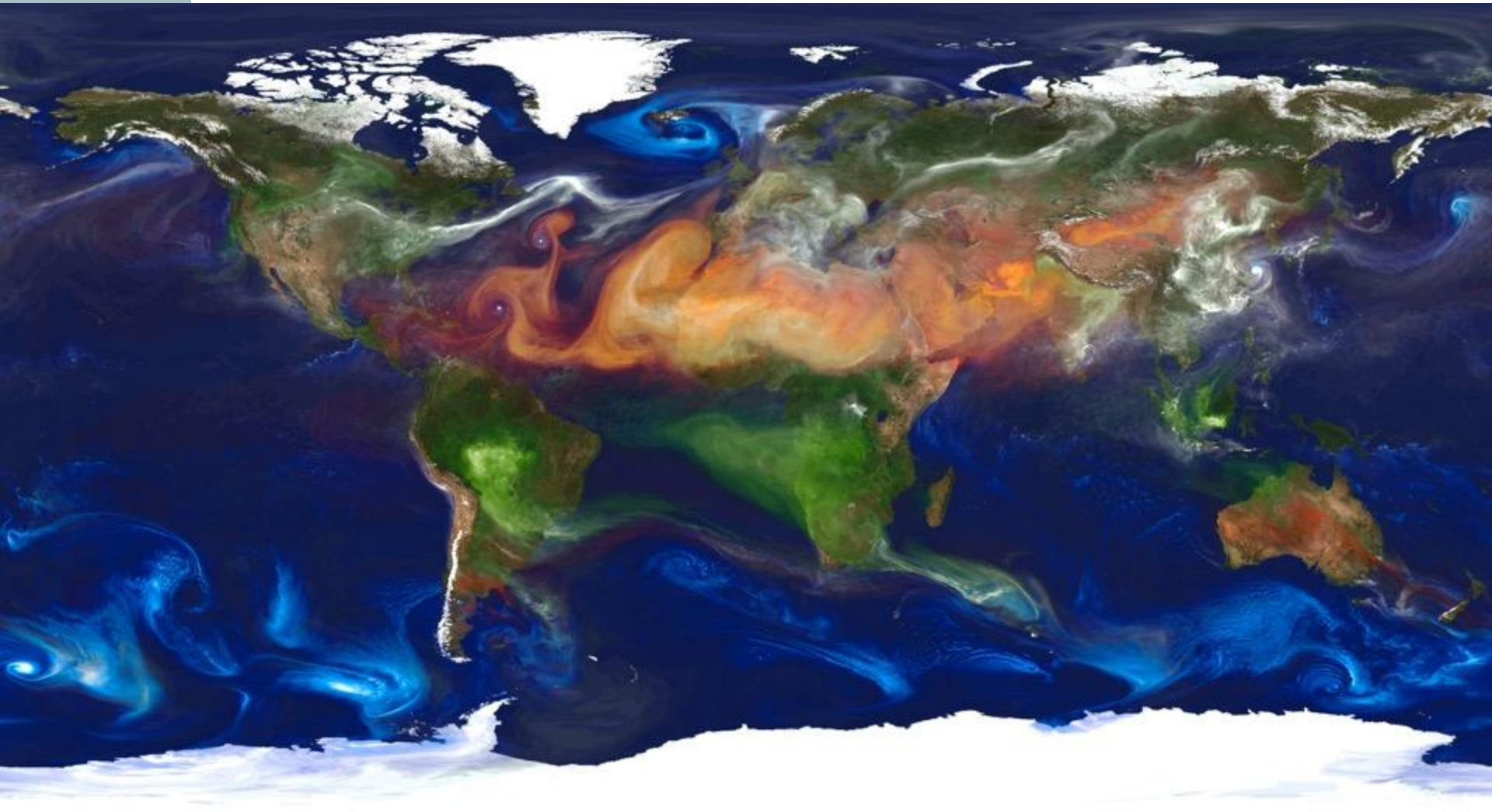


Atmosphere



Aerosols

# Protocol Training Aerosols





# Overview and Learning Objectives

## Overview

*This module:*

Describes how to measure aerosol optical thickness (AOT) using one of two instrument options (GLOBE Sun Photometer or Calitoo)

## Learning Objectives

*After completing this module, you will be able to:*

- Describe what aerosols are and what AOT measurements mean
- List reasons why it is important to collect measurements of AOT
- Identify appropriate conditions and locations to take AOT measurements

A. What are aerosols?

B. Why collect aerosol data?

C. How your measurements can help!

D. How to collect your data.

E. How to report your data to GLOBE.

F. Understand the data.

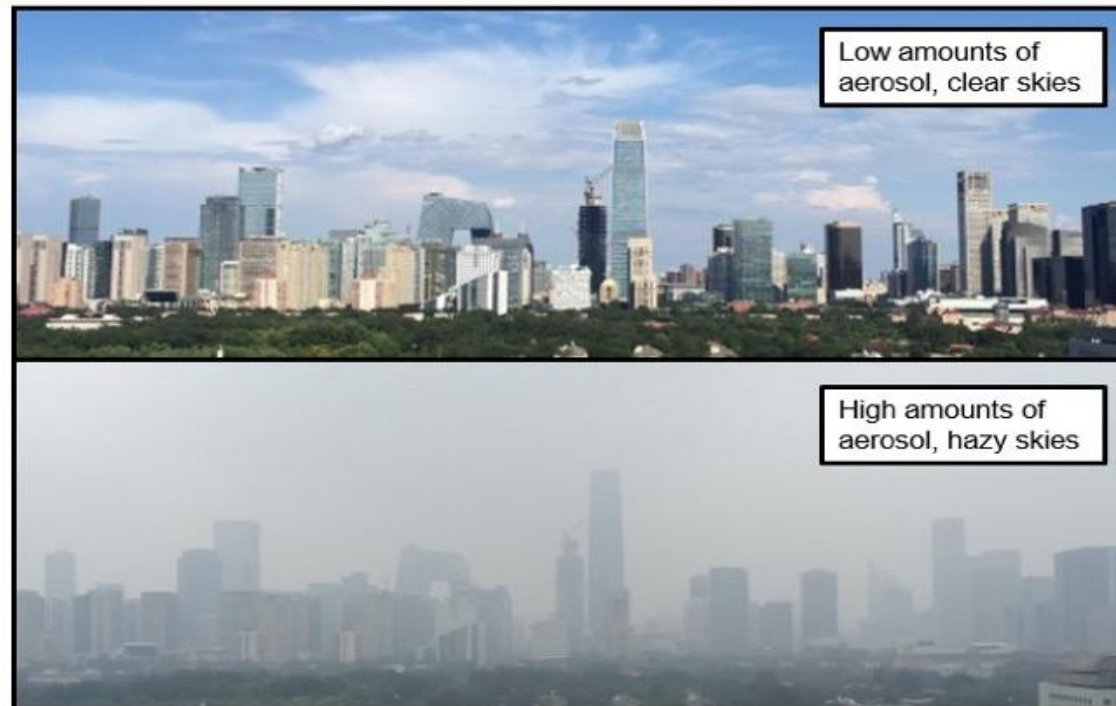
G. Quiz yourself!

H. Further resources.



# What are Aerosols?

With every breath, you inhale millions of solid and liquid particles called **aerosols**. Despite their small size, aerosols have a significant impact on climate and health. They may also affect visibility. On days when there are lower amounts of aerosols, distant details are easily visible. During a pollution event, the skies are hazy, and visibility is reduced.



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## What are Aerosols? – 2

- Aerosols are mixtures of liquid or solid particles suspended in a gas, for example, air.
- These particles range in size from a fraction of a micrometer ( $\mu\text{m}$ , or one millionth of a meter) to a few hundred micrometers.
- They are formed by natural processes or as a result of human activity.
- Smoke, bacteria, salt, pollen, dust, various pollutants, ice, and tiny droplets of water are all aerosols.
- They have mixed effects on the energy balance of the atmosphere.

## GLOBE Atmosphere Protocols

**Aerosols**

**Air Temperature**

**Barometric Pressure**

**Clouds**

**Precipitation**

**Relative Humidity**

**Surface Ozone**

**Surface Temperature**

**Water Vapor**

**Wind**



# Meet Aero-SOL



This video, produced by the French Space Agency CNES, explains the role of aerosols in Earth's climate and how scientists make measurements of aerosols from orbiting satellites. [Climate Mission: Secrets of Aerosols and Clouds](#)  
Click [here](#) for a YouTube version of this video that can be closed-captioned.  
Click [here](#) for a described version of this video.

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# There Are Many Ways to Measure Aerosols And Many Names for Aerosol Data

There are many methods available to determine how much aerosol is present during an observation. Different measurement types use different terminology for aerosols, some of which you may see in other places. Below is a short summary of some common terms.

Term	Explanation
Aerosol	A mixture of solid and liquid particles suspended in air
<b><i>Aerosol optical depth/thickness (AOT)</i></b>	<b><i>The measurement terminology used by GLOBE, explained further in this eTraining</i></b>
Particulate matter or PM (PM <sub>2.5</sub> or PM <sub>10</sub> )	A term most commonly used for particles collected from air, often in order to study their chemical composition
micrograms per meter cubed ( $\mu\text{g}/\text{m}^3$ )	PM is expressed as concentration, or amount of substance X in a fixed amount of total sample

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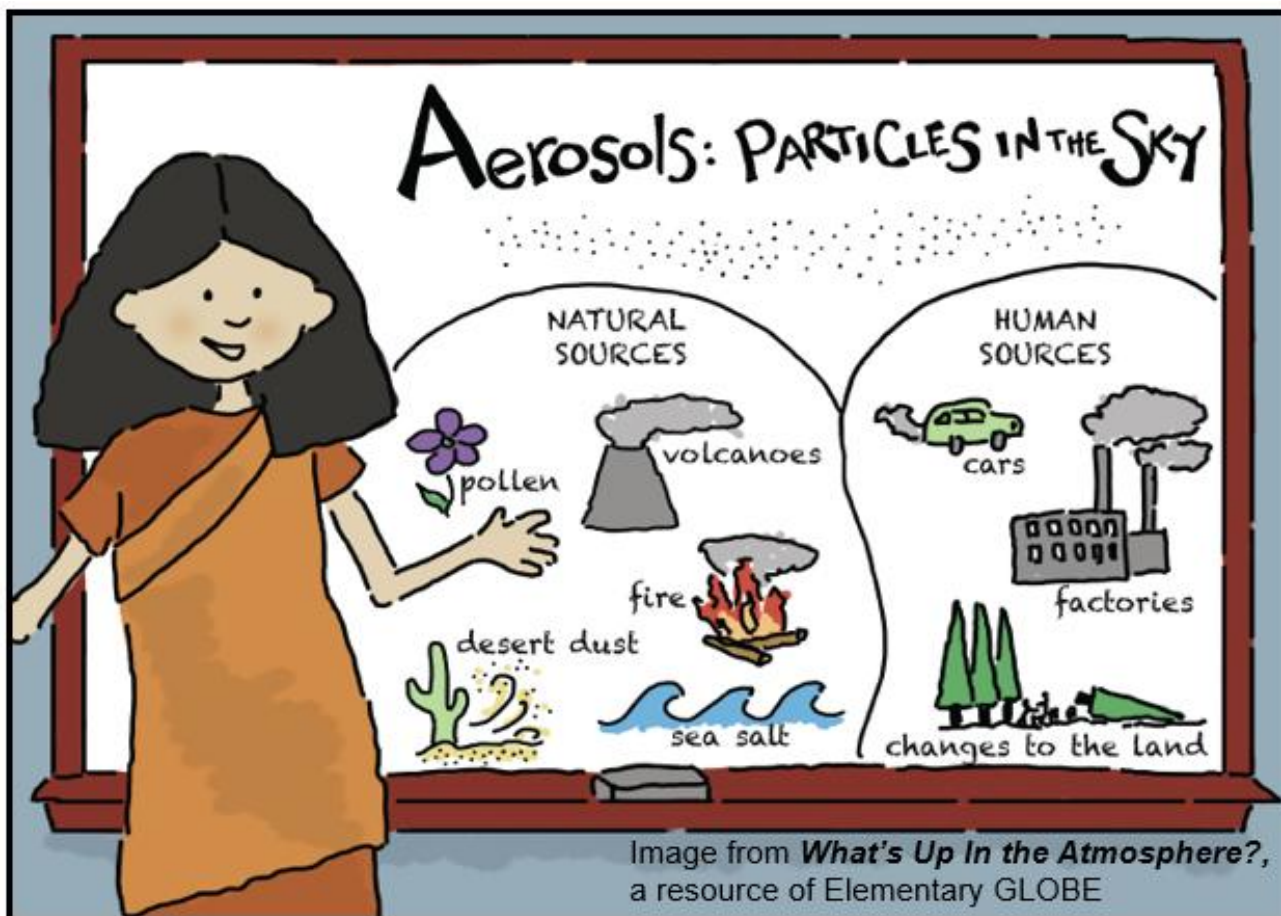
F. Understand the data.

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# Aerosols: Particles in the Sky

Aerosols come from many different sources. Some are ***anthropogenic***, or human-caused, and some are natural. Various sources emit different sized particles which can alter the effects those aerosols have on planet Earth.







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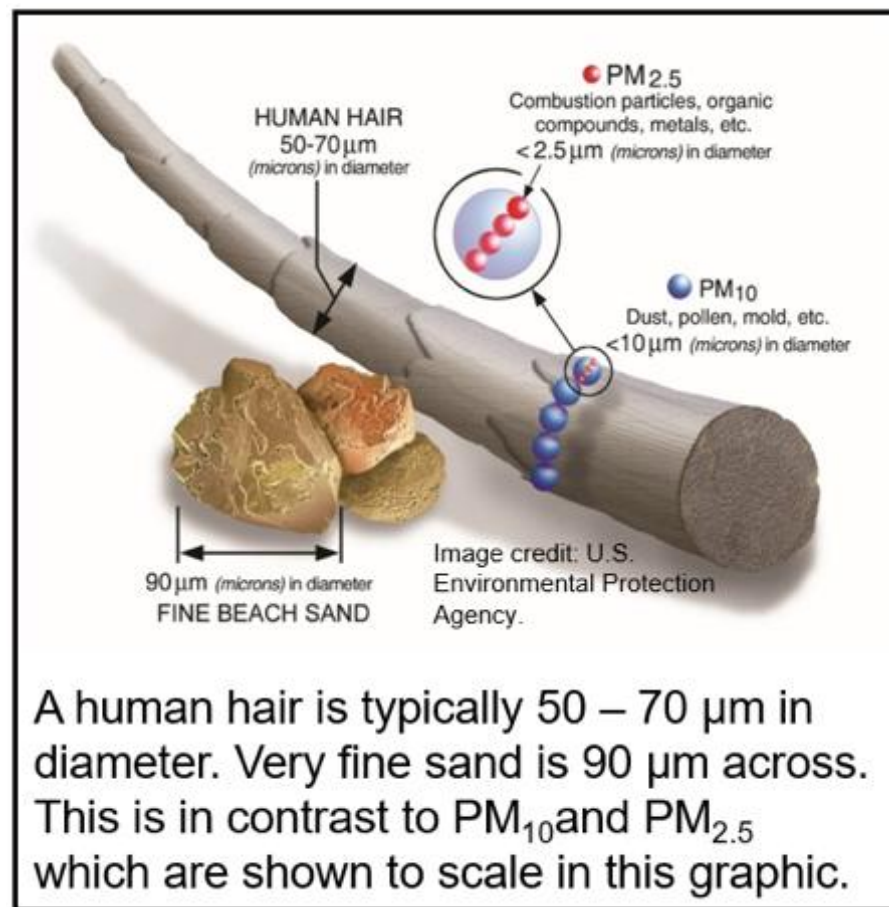
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# A Closer Look at Particles

The size of a particle gives scientists clues about its origin and composition. Larger particles tend to form when salt, sand, or ash is blown into the air by strong winds. Dust, pollen, and mold all form medium-sized aerosols, while the smallest particles come from combustion processes or chemical reactions.

Particles are sometimes labeled in terms of diameter.  $PM_{10}$  and  $PM_{2.5}$  are particles that are smaller than 10 and 2.5  $\mu m$  across, respectively.







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## Aerosols Come In Different Sizes

The size of a particle defines how it will interact with different colors of light. Every particle type has a characteristic combination of light interactions that scientists use as “fingerprints” to identify aerosols of various sizes and compositions.



Aerosols come from many sources. Sea salt, dust, and volcanic ash (shown right) tend to form larger particles, while soot and particles formed from chemical reactions are usually much smaller.





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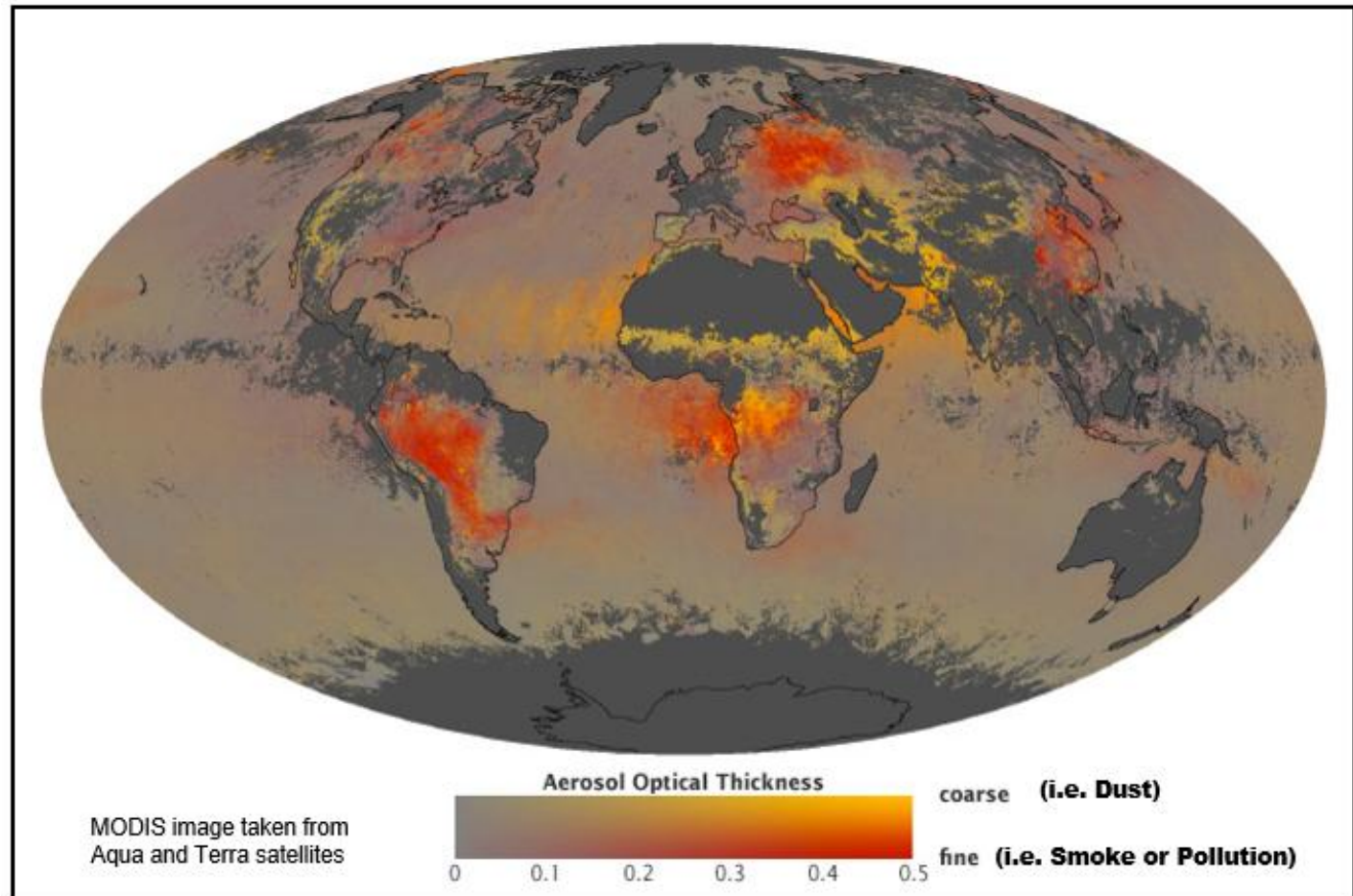
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## Aerosols From Different Sources Have Different Sizes

This map shows the diversity in particle size as well as the amounts of aerosols across the world as seen from space. Yellow areas have lots of dust or sand, while red areas are indicative of pollution or smoke.







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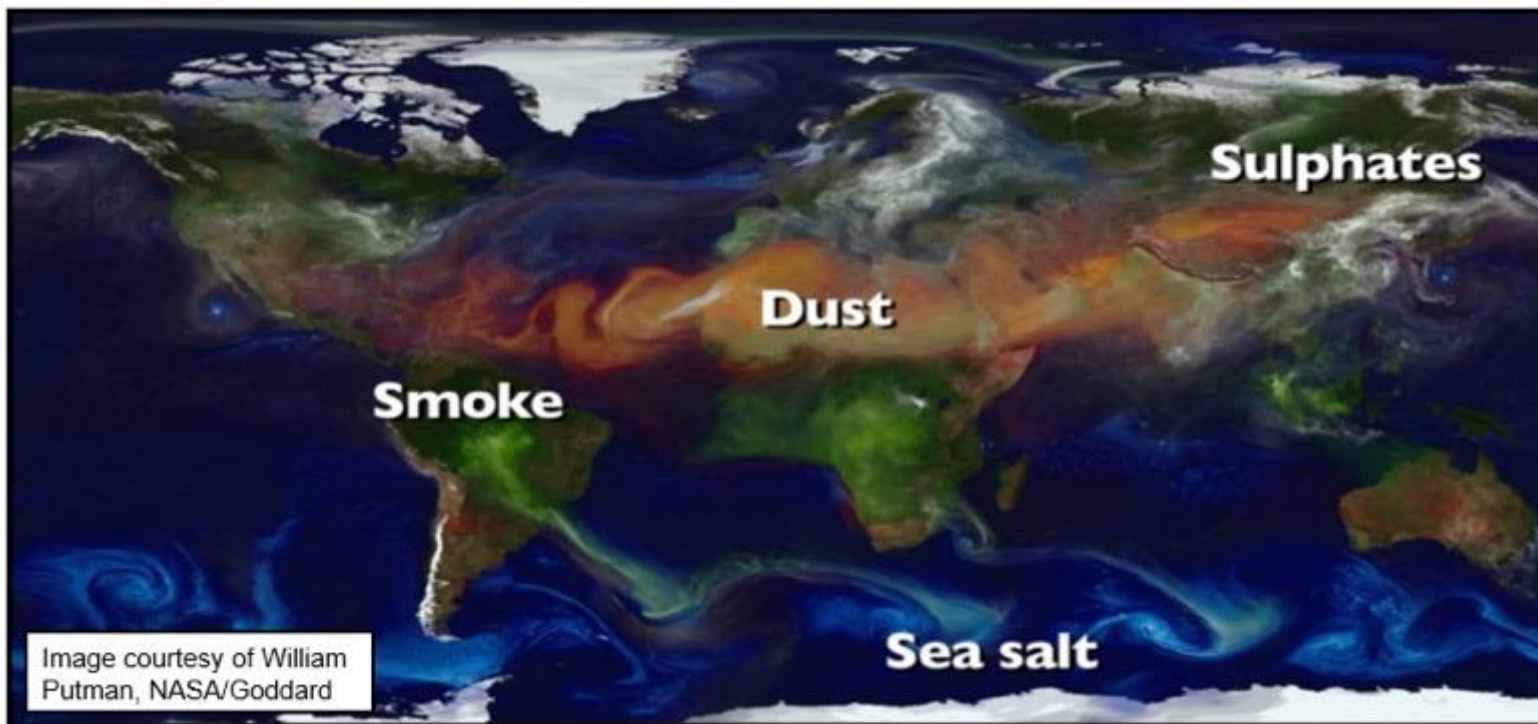
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# Aerosols Impact Air Quality Across the Globe

Aerosols can form in one part of the world and travel many miles to affect the air quality in distant regions. Regular measurements help scientists make better predictions about the effects these global travelers will have on our health and the health of our environment. This map of Earth shows many types of aerosols emitted across the globe and how what may seem like very local air quality problems can, in fact, travel across the world to have large impacts on far-away places.



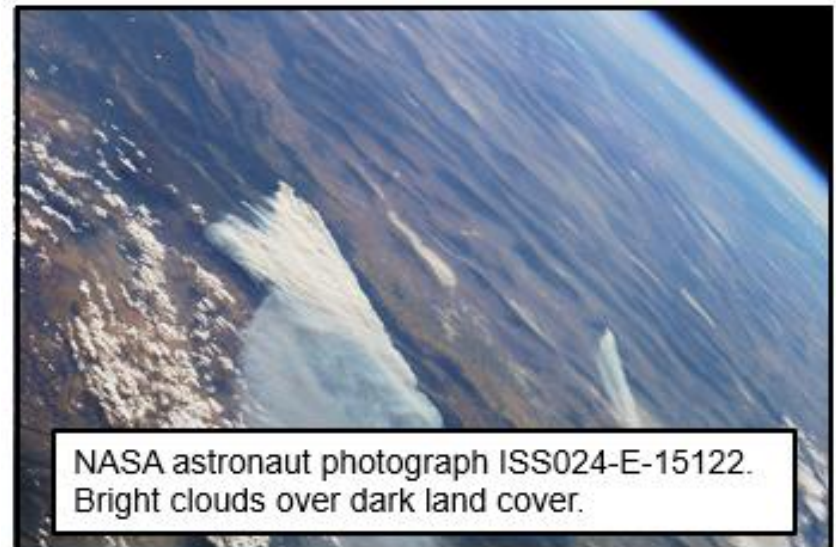
[Click here for an animated version of this map showing global aerosols from 2005-2007](#)



# Aerosols Can Affect Climate Directly

By increasing or decreasing the amount of sunlight that reaches the Earth's surface, aerosols can have direct heating or cooling effects on climate. Some aerosols (top), like light-colored sulfates from volcanoes or human activities, reflect light away from the surface and have a cooling effect. Others (below) can settle onto previously bright areas and cause warming, like black carbon on snow leading to increasing melting.

[See here for more information on how dark-colored aerosols can influence snow melt.](#)



NASA astronaut photograph ISS024-E-15122.  
Bright clouds over dark land cover.



Image courtesy of New Zealand GeoNet, 2007.  
Soot settles on snow, turning it grey and black.

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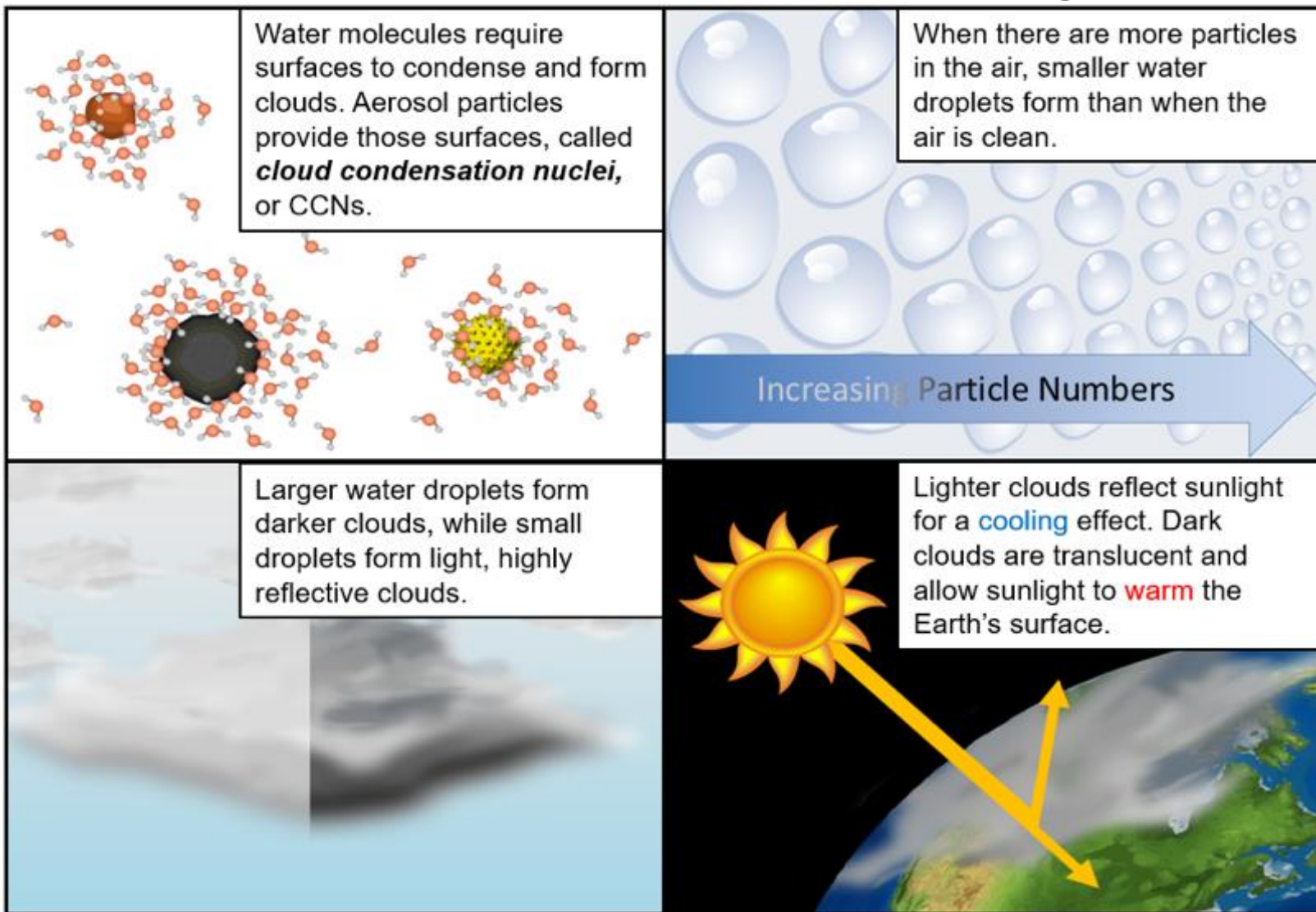
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## Aerosols Influence Earth's Climate Through Clouds





# Aerosols Influence Many Things On Earth, But We Still Have Lots of Questions

- How do aerosol concentrations vary with seasons?
- How are aerosols related to weather and climate?
- How does smoke from large fires affect sky color and clarity?
- How long do volcanic emissions stay in the atmosphere, and where do they go?
- How do industrial facilities and agricultural activities affect aerosols?

Scientists around the world collect data to answer these and many other questions about aerosols and their effects on our global environment.

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# GLOBE Measurements Help Scientists:

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Your observations are valuable contributions to the scientific community and may be used by educators, students, researchers, and the general public to increase environmental awareness and STEM literacy, as well as advance Earth system science.

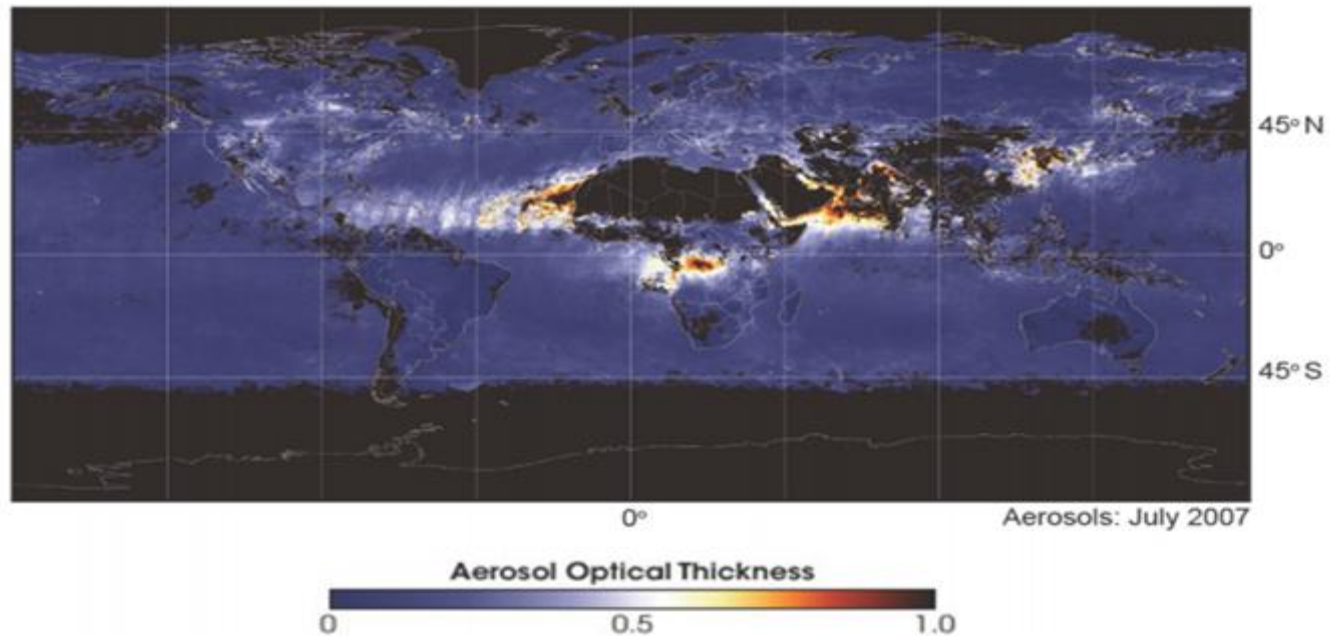






# Scientists Quantify Aerosols Using Measurements of Aerosol Optical Thickness

**Aerosol Optical Thickness** (AOT, also called aerosol optical depth) is a measure of how much of the Sun's light is prevented from reaching the Earth's surface due to scattering and absorption by aerosols.



This map ([and more like it](#)) shows measurements of aerosol optical thickness as seen from space. Clear skies usually have low AOT values (0.1 or lower) while regions with AOT values greater than 0.3 are often experiencing an aerosol event such as a wildfire, a dust storm, or a pollution event. Note that AOT values greater than 1, while not shown here, are possible.

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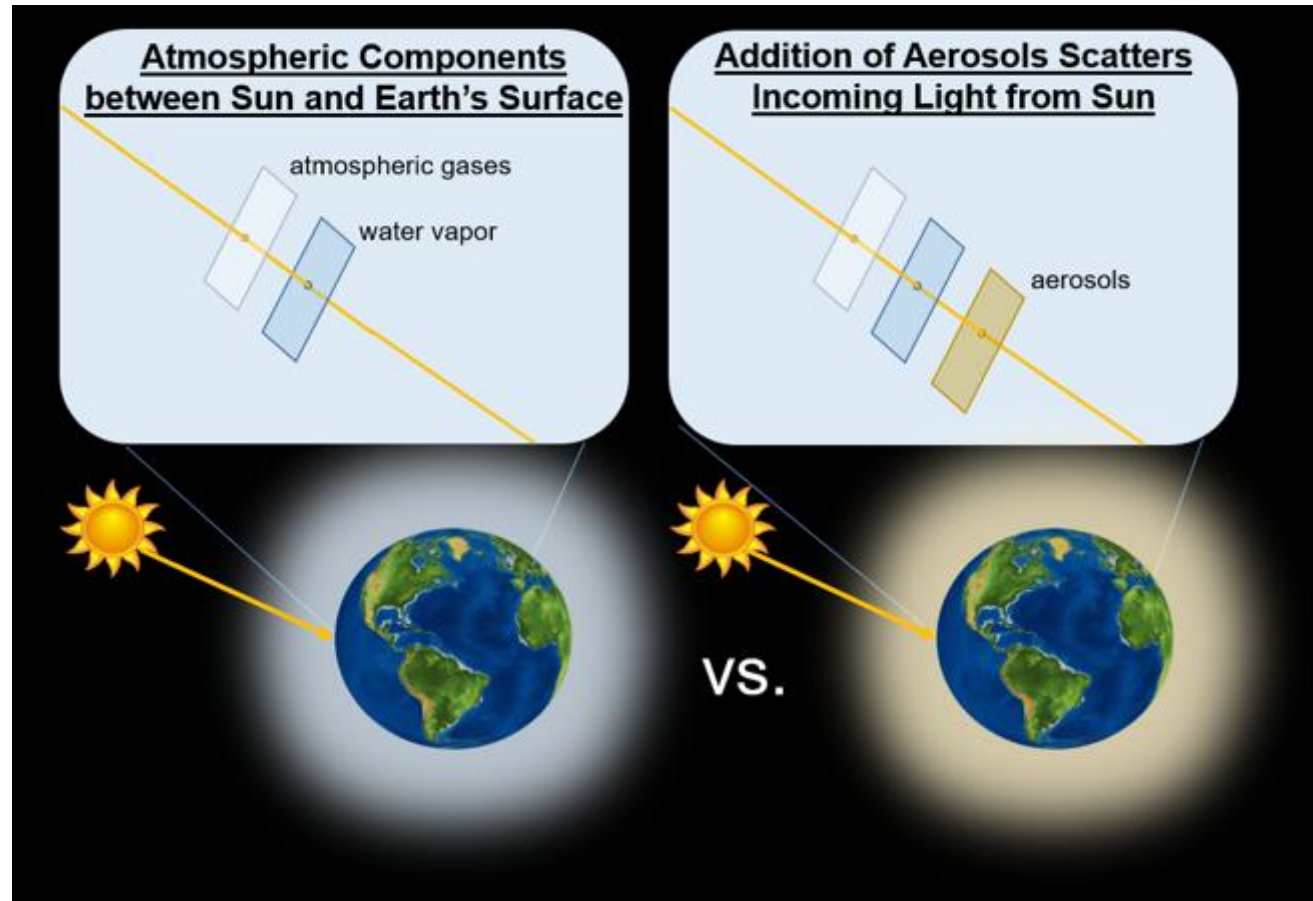
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# What is Aerosol Optical Thickness?

Aerosol optical thickness is a comparison of the amount of light from the Sun that could reach the Earth's surface if no aerosols were in the way and the amount of sunlight actually measured from your atmospheric study site.



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## We Measure AOT from the Ground

Sun photometers like those shown on the right measure AOT from the ground looking upwards, towards the Sun. These instruments measure AOT at several wavelengths to learn about the size distribution and sources of the aerosols. The larger the optical thickness, the less light reaches Earth's surface. The more aerosols in the atmosphere, the greater the AOT value will be.

**More aerosol ↔ Higher AOT**



**Less light at the surface**



Image by Ovidiu Pancrati, ©2007 CANDAC.



Image courtesy of AERONET.



# Before You Begin the Aerosols Protocol

Before you begin taking Aerosol observations, you will need to have already identified your [Atmosphere Study Site](#). In order to submit aerosol measurements, you must also collect [Clouds](#) and [Barometric Pressure](#) observations. Please review these protocols first.

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# How to Collect: Overview

- **Where?** At your Atmosphere Site (see [Documenting Your Atmosphere Study Site](#))
- **When?** Mid-morning, or any time you have an unobstructed view of the Sun (meaning no clouds between you and the Sun!)
- **How?** Using GLOBE Sun photometer or a Calitoo
  - Shade or Microtops instruments are not covered in this training
- **Other observations:**
  - [Clouds](#) (*required for all aerosol measurements*)
  - [Barometric Pressure](#) (*required if using a GLOBE Sun photometer*)
  - [Sky Color & Visibility](#) (optional)
  - [Current Air Temperature](#) (optional)
  - [Relative Humidity](#) (optional)

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# What You Will Need

## Required:

- GLOBE Sun photometer OR a Calitoo
- Watch, smart device, GPS, or other instrument that reports time to the second (recorded as HH:MM:SS)
- [Aerosols Data Sheet](#)
- [GLOBE Cloud Chart](#)
- Field guides for [cloud cover](#) and [cloud type](#)
- Pen or pencil
- Clipboards

## Optional:

- Barometer\*\*
- Hygrometer or sling psychrometer
- Thermometer for air temperature
- Field guides for [barometric pressure](#), relative humidity ([digital hygrometer](#) or [sling psychrometer](#)), and [air temperature](#)

\*\* Pressure may also be obtained from local weather station, but we do not recommend using the built-in sensor on the Calitoo.

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# Be Sure to Record Everything About Your Study Site to Make Your Data Count!

## Atmosphere Investigation Aerosols Data Sheet

\* Required Field

School Name: \_\_\_\_\_ Study Site: \_\_\_\_\_

Observer names: \_\_\_\_\_

Date: Year \_\_\_\_\_ Month \_\_\_\_\_ Day \_\_\_\_\_ Universal Time (hour:min): \_\_\_\_\_

**\*Sun Photometer Instrument Type (Check One):**

☐ Measures Voltage Only (Serial Number): \_\_\_\_\_ ☐ Displays AOT (Model) \_\_\_\_\_

**\*If known, Satellite overflights on date of measurements:**

Satellite/instrument name: \_\_\_\_\_ Time of overflight (UT): \_\_\_\_\_ Max elevation angle (deg): \_\_\_\_\_

Without this critical information about your atmosphere study site, you won't be able to enter your data into GLOBE. You also won't be able to calculate accurate AOT values or compare them against future measurements. Experimental context is vital for scientific discovery!



Atmosphere



Aerosols

# Complete the Entire Protocol for the Most Investigation Opportunities

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**Atmosphere Investigation**  
Aerosols Data Sheet

School Name: \_\_\_\_\_ Study Site: \_\_\_\_\_  
Observer name: \_\_\_\_\_  
Date: Year \_\_\_\_\_ Month \_\_\_\_\_ Day \_\_\_\_\_ Universal Time (hour min): \_\_\_\_\_

\*Sun Photometer Instrument Type (Check One):  
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☐ Serial Number \_\_\_\_\_

\*If known, Satellite overflights on date of measurements:  
Satellite/instrument name: \_\_\_\_\_ Time of overflight (UT): \_\_\_\_\_ Max elevation angle (deg): \_\_\_\_\_

**If Your Photometer Only Measures Voltages:**

Case Temperatures  
Before taking measurements (multiply voltage reading by 100) (°C) \_\_\_\_\_  
After taking measurements (multiply voltage by 100) (°C) \_\_\_\_\_

\*At least 3 sets of measurements are required.  
\*Always report voltages with 3 digits to the right of the decimal point (e.g., 1.733 rather than 1.73).

Measurement Number *	Universal Time (hour minute second)	Maximum Voltage in Sunlight *	Dark Voltage *
1 (green)			
2 (red)			
3 (red)			
4 (green)			
5 (red)			
6 (red)			

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Atmosphere Investigation: Aerosols Data Sheet - Page 2

Study Site: \_\_\_\_\_ Date: \_\_\_\_\_ Time (UT): \_\_\_\_\_

\* Required Field

**If Your Photometer Displays AOT:**

\*At least 3 sets of multiple wavelengths are required.  
\*At least two different channel wavelengths must have been used among the 3 to 5 measurements.

Wavelength (nm)	Channel Wavelength *	AOT reading
1		
2		
3		

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Atmosphere Investigation: Cloud Protocol Data Sheet

School/Observer Name: \_\_\_\_\_ Study Site: \_\_\_\_\_  
Date (ex. 2017 01 13): Year \_\_\_\_\_ Month \_\_\_\_\_ Day \_\_\_\_\_  
Time (ex. 24 Hour Clock: 14:30): Local Hour \_\_\_\_\_ Minute \_\_\_\_\_ Universal Hour \_\_\_\_\_ Minute \_\_\_\_\_

**1. What is in Your Sky?**

Total Cloud/Coveral Cover:  
☐ Sky is Obscured  
☐ None (Go to box 2)  
☐ Scattered (25-50%)  
☐ Broken (50-90%)  
☐ Overcast (90-100%)

☐ Fog  
☐ Heavy Rain  
☐ Heavy Snow  
☐ Blowing Snow  
☐ Sand  
☐ Spray  
☐ Smoke  
☐ Volcanic Ash  
☐ Haze  
☐ Dust

**2. Sky Color and Visibility**

Color (see key): ☐ Cannot Observe ☐ Deep Blue ☐ Blue ☐ Light Blue ☐ Pale Blue ☐ Milky  
Visibility (see key): ☐ Cannot Observe ☐ Usually Clear ☐ Clear ☐ Somewhat Hazy ☐ Very Hazy ☐ Extremely Hazy

**3. High Level Clouds**

☐ No High Level Clouds Observed (Go to box 4)  
Cloud Type: ☐ Cirrus ☐ Cirrocumulus ☐ Cirrostratus  
Cloud Cover: ☐ Few (<10%) ☐ Isolated (10%-25%) ☐ Scattered (25%-50%) ☐ Broken (50%-90%) ☐ Overcast (>90%)  
Visual Opacity: ☐ Opaque ☐ Translucent ☐ Transparent

**4. Mid Level Clouds**

☐ No Mid Level Clouds Observed (Go to box 5)  
Cloud Type: ☐ Altostratus ☐ Altimcumulus  
Cloud Cover: ☐ Few (<10%) ☐ Isolated (10%-25%) ☐ Scattered (25%-50%) ☐ Broken (50%-90%) ☐ Overcast (>90%)  
Visual Opacity: ☐ Opaque ☐ Translucent ☐ Transparent

**5. Low Level Clouds**

☐ No Low Level Clouds Observed (Go to box 6)  
Cloud Type: ☐ Fog ☐ Stratus ☐ Cumulus ☐ Cumulonimbus ☐ Stratocumulus  
Cloud Cover: ☐ Few (<10%) ☐ Isolated (10%-25%) ☐ Scattered (25%-50%) ☐ Broken (50%-90%) ☐ Overcast (>90%)  
Visual Opacity: ☐ Opaque ☐ Translucent ☐ Transparent

**6. Surface Conditions**

Mandatory:  
Snow/ice: ☐ Yes ☐ No  
Standing Water: ☐ Yes ☐ No  
Mud: ☐ Yes ☐ No  
Leaves on Trees: ☐ Yes ☐ No  
Rain/Snowing: ☐ Yes ☐ No

Optional:  
You may submit any or all:  
Temperature: \_\_\_\_\_ °C  
Barometric Pressure: \_\_\_\_\_ mb  
Relative Humidity: \_\_\_\_\_ %

Comments: \_\_\_\_\_

GLOBE 2017 ATMOSPHERE





# Instrument Options



## GLOBE Sun Photometer

Reads voltage at 2 wavelengths

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“green” at 505nm

“red” at 625 nm

Click [HERE](#) for instructions on using the GLOBE Sun Photometer

## Calitoo Photometer

Reads AOT at 3 wavelengths

“blue” at 465 nm

“green” at 540 nm

“red” at 619 nm

Click [HERE](#) for instructions on using the Calitoo

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# Using a GLOBE Sun Photometer (1)

This instrument records voltage. The GLOBE website calculates AOT values. Your GLOBE Sun photometer will collect the following data:

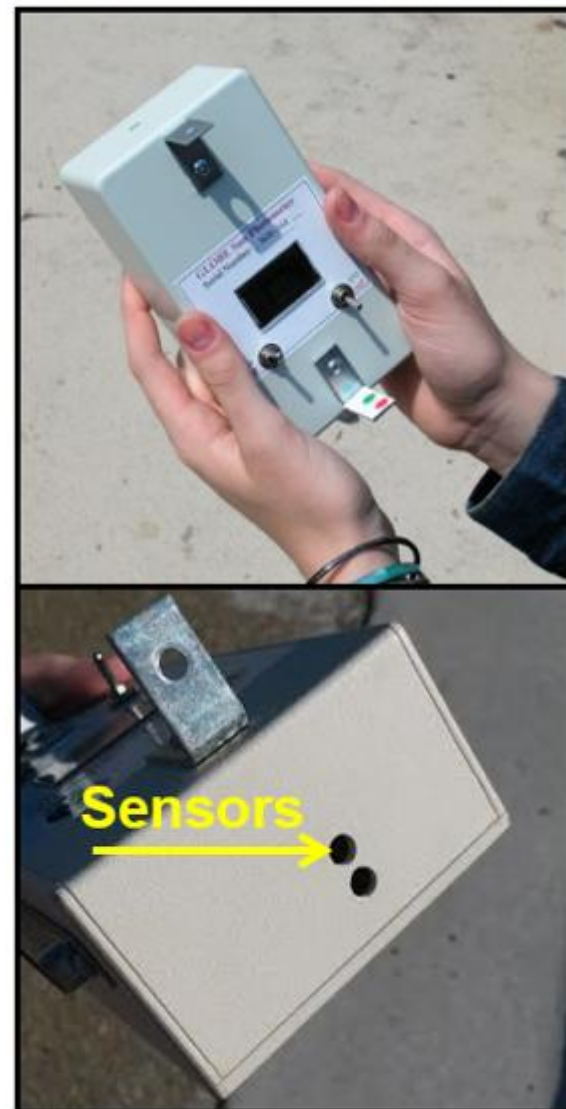
- Voltage at red and green wavelengths
- Voltages with sensors shielded from the Sun (the “dark voltages”)
- Instrument temperature before and after you begin your measurements

You **must** also collect the following information:

- Date and time
- Instrument serial number
- Barometric pressure at your site
- Cloud cover and cloud type

You **may** collect:

- Current air temperature
- Sky color and visibility





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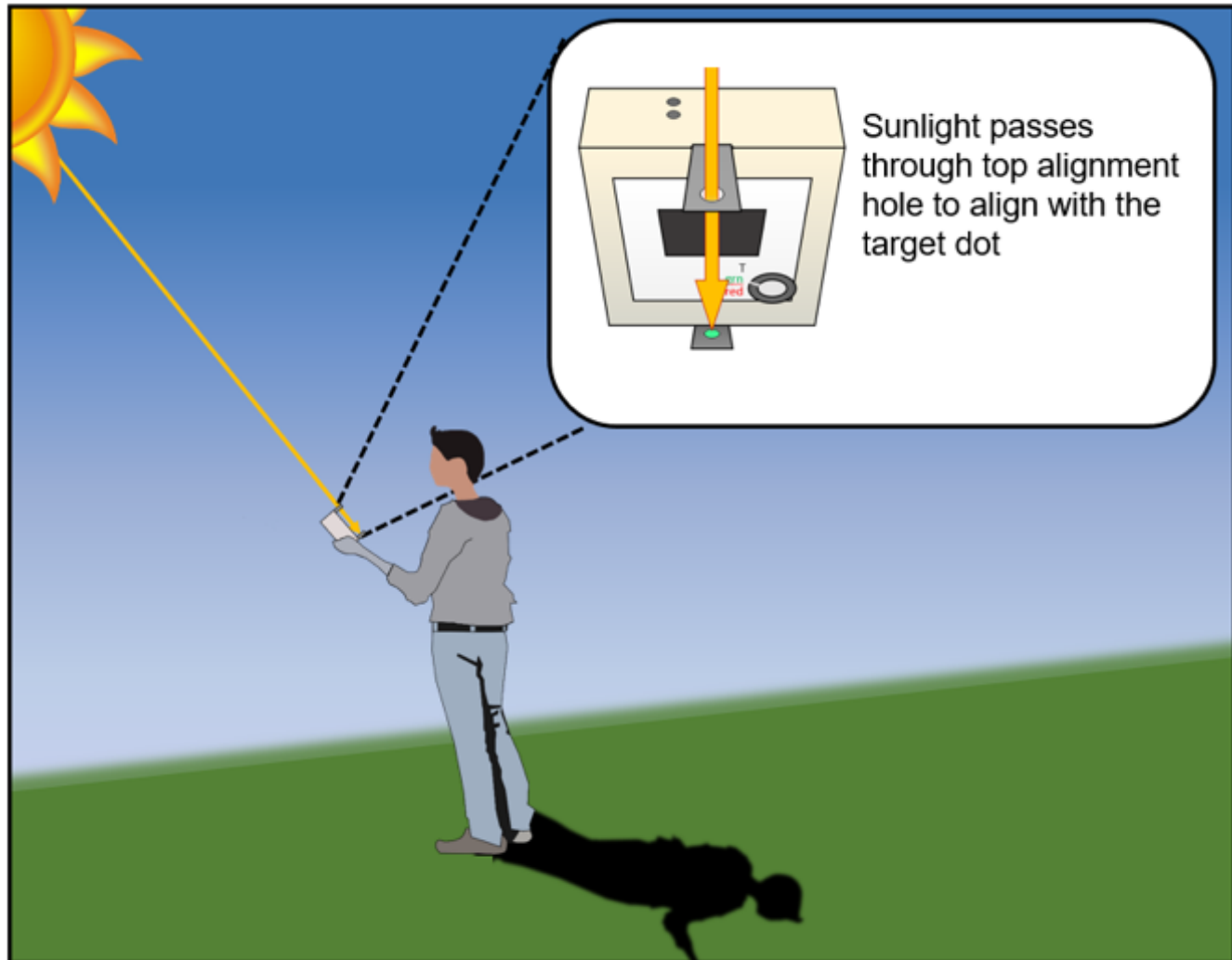
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## Using a GLOBE Sun Photometer (2)

- 1) Turn on the instrument.
- 2) Turn the measurement dial to temperature “T” and record the initial temperature.
- 3) Turn the dial to green or “grn.”
- 4) Point the top of the photometer at the Sun. Align the light dot coming through the top tab of the photometer with the target dot on the bottom tab.
- 5) Cover the light sensors completely and record the maximum voltage for the “dark voltage.”
- 6) Uncover the sensors and record the maximum voltage.
- 7) Turn the measurement dial to red.
- 8) Repeat steps 5 and 6 for the red voltage.
- 9) Repeat steps 2-8 at least three times.
- 10) Turn the measurement dial to temperature “T” and record the end temperature.



## Using a GLOBE Sun Photometer (3) Aligning with the Sun



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# Using a Calitoo (1)

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This instrument records AOT. Your Calitoo will collect the following data:

- AOT at red, green, and blue wavelengths
- GPS location and elevation

You **must** also collect the following information:

- Date and time
- Instrument serial number
- Cloud cover and cloud type

You **may** collect:

- Current air temperature\*
- Sky color and visibility
- Barometric pressure at your site\*

\* Do not use the Calitoo for these measurements. It does not provide accurate measurements of its surroundings.





## Using a Calitoo (2)

- 1) Turn the instrument on by pressing and holding the front button down.
- 2) Wait until the GPS signal is found. The screen will show ">>" or "<<" when searching and "3D" when the location is locked.
- 3) Make sure the instrument is in the measuring mode.
- 4) Point the top of the Calitoo directly at the Sun. Align the Sun dot on the front of the instrument with the center of the target.
- 5) Keeping the Sun dot aligned, press the button on the front of the instrument. The values on the screen will fluctuate.
- 6) When the values are maximized, press the button again. The screen will display the AOT values you just measured.
- 7) Press the button again\*. The screen will say "Recording #/999 OK?" where # is the number of measurements saved on the Calitoo including this new one.
- 8) To store the data, hold the button down until the screen says "Recorded!"
- 9) Repeat steps 3-8 at least twice more.

\* You will want to practice with this instrument before taking measurements. The length of time required for each button press varies slightly for different instruments. Make sure the messages on the screen match those in the instructions and consult the additional documentation if you encounter problems.

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E. How to report your data to GLOBE.

F. Understand the data.

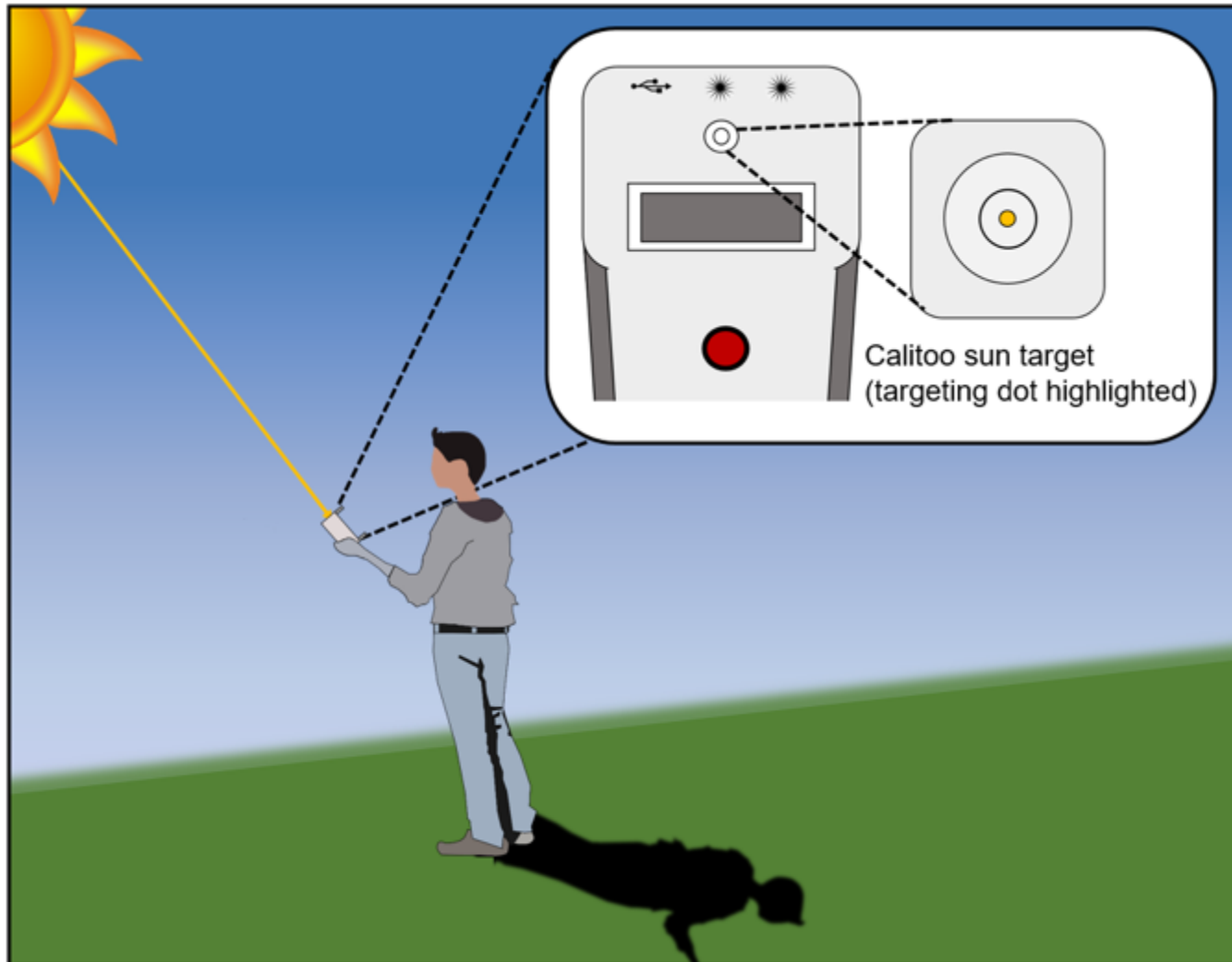
G. Quiz yourself!

H. Further resources.



- A. What are aerosols?
- B. Why collect aerosol data?
- C. How your measurements can help!
- D. How to collect your data.**
- E. How to report your data to GLOBE.
- F. Understand the data.
- G. Quiz yourself!
- H. Further resources.

## Using a Calitoo (3) Aligning with the Sun





# Common AOT Measurement Mistakes

The Sun photometer must be aligned correctly with the Sun to make accurate measurements. Follow the instructions for aligning your photometer carefully, and refer to the additional, instrument specific eTraining modules if you encounter difficulties.

**NO CLOUDS MAY OBSTRUCT THE LINE OF SIGHT (NO CLOUDS IN FRONT OF THE SUN) FOR YOUR MEASUREMENT!** Clouds will cause artificially high AOT values.

Keep the instruments indoors until right before you are ready to make a measurement. Don't let your Sun photometer get too cold or too hot—large changes in temperature can cause the instruments to report inaccurate measurements.

Record your measurements both on the instrument (if applicable) and on paper or another medium; it is easy to lose data from an instrument and having a backup record will prevent losing entire measurements.

A. What are aerosols?

B. Why collect aerosol data?

C. How your measurements can help!

**D. How to collect your data.**

E. How to report your data to GLOBE.

F. Understand the data.

G. Quiz yourself!

H. Further resources.





A. What are aerosols?

B. Why collect aerosol data?

C. How your measurements can help!

**D. How to collect your data.**

E. How to report your data to GLOBE.

F. Understand the data.

G. Quiz yourself!

H. Further resources.

# Sky Color and Visibility Observations Give Your Data Context

Sky color is a visual indication of the quantity of aerosols in the atmosphere. Aerosols tend to scatter all wavelengths of light, making the sky look more white. A deep blue sky suggests very few aerosols. A milky sky suggests there are lots of aerosols.

Note: Sky color can only be observed from a clear section of sky, with no clouds in view.

## How to observe sky color:

- Turn your back to the Sun.
- Look at the sky halfway between the horizon and straight up ( $45^\circ$ ).
- Pick the shade that most closely matches your sky.
- You want to match the color of the sky, not the clouds, so if it's too cloudy you may not be able to observe sky color.

< Overall Sky Conditions

What color is the deepest shade of blue in the sky?

Deep Blue

☐

Blue

☐

Light Blue

☐

Pale Blue

☐

Milky

☐



A. What are aerosols?

B. Why collect aerosol data?

C. How your measurements can help!

**D. How to collect your data.**

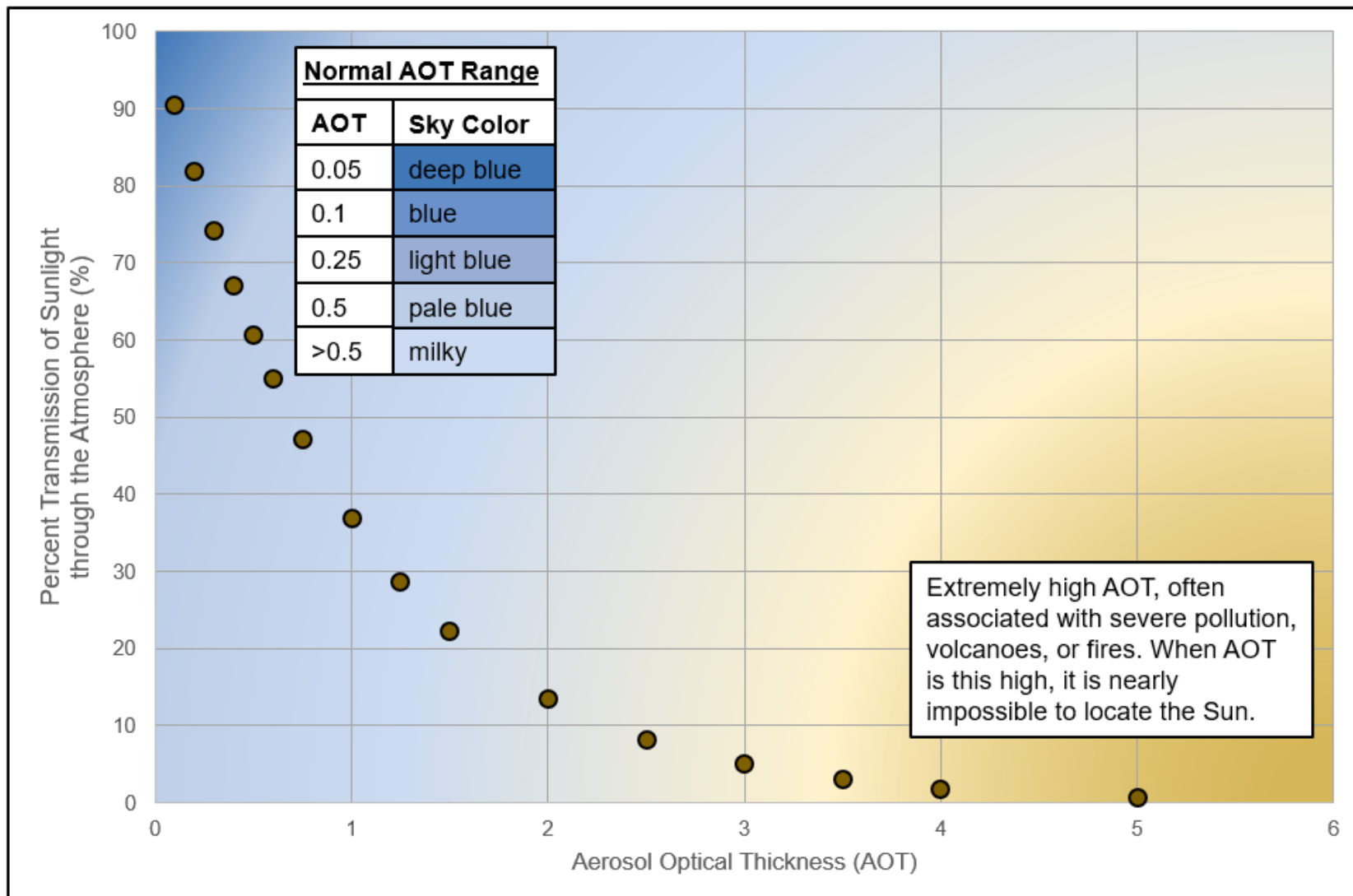
E. How to report your data to GLOBE.

F. Understand the data.

G. Quiz yourself!

H. Further resources.

## As AOT Increases, the Amount of Light Reaching Earth's Surface Directly Decreases Rapidly, Going to Near Zero in Severe Pollution Events





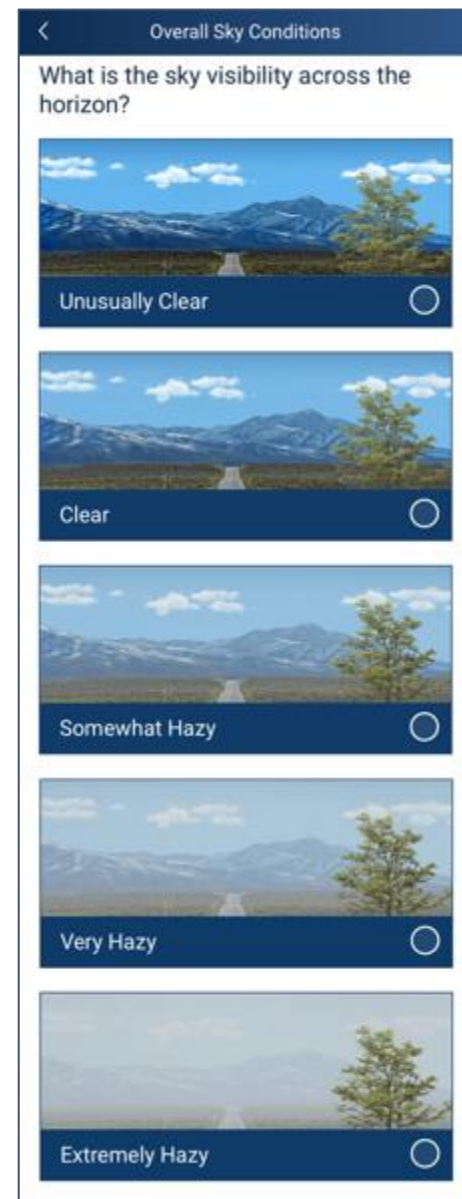
## Sky Color and Visibility Observations Give Your Data Context

Sky visibility is an indication of the quantity of the aerosols close to the surface of the ground. The more aerosols there are, the more haze will appear. For more information on sky color and visibility, please consult the [Clouds Protocol](#).

### How to observe visibility:

- Look at a landmark in the distance.
- Try to use the same landmark every time.

Tip: It can be helpful to take a picture of your sky day-to-day to notice the difference between visibility observations. In addition, the clearest sky for your area will be seen just after a front or a storm moves through your area.



A. What are aerosols?

B. Why collect aerosol data?

C. How your measurements can help!

**D. How to collect your data.**

E. How to report your data to GLOBE.

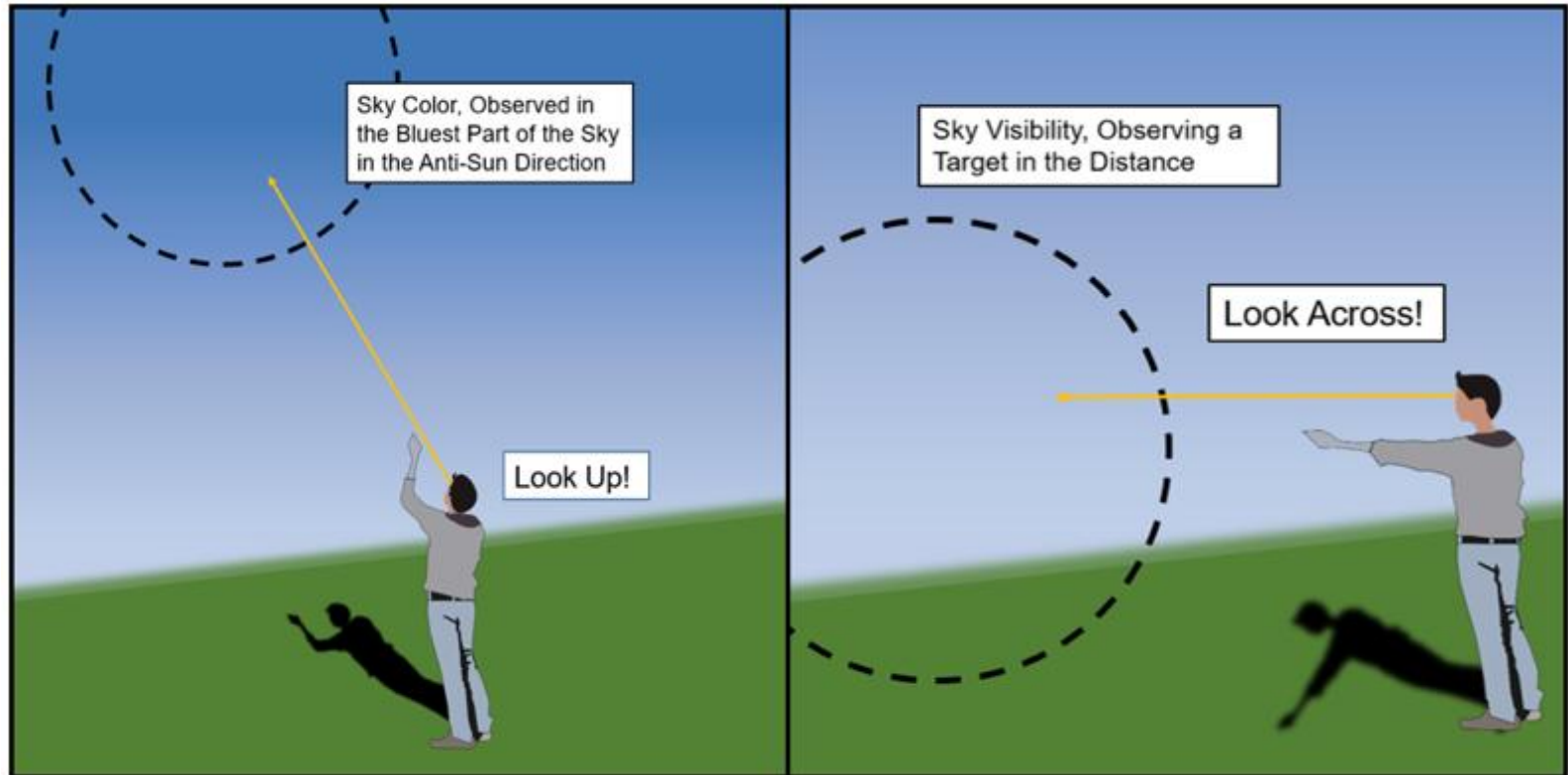
F. Understand the data.

G. Quiz yourself!

H. Further resources.



# How to Observe: Sky Conditions



Here's a good reminder for the difference between observing sky color and sky visibility, and where to look as you observe each.

- A. What are aerosols?
- B. Why collect aerosol data?
- C. How your measurements can help!
- D. How to collect your data.**
- E. How to report your data to GLOBE.
- F. Understand the data.
- G. Quiz yourself!
- H. Further resources.





- A. What are aerosols?
- B. Why collect aerosol data?
- C. How your measurements can help!
- D. How to collect your data.
- E. How to report your data to GLOBE.**
- F. Understand the data.
- G. Quiz yourself!
- H. Further resources.

# Entering Aerosol Data in the GLOBE Observer Data Entry System

## Two Options for Uploading Data:

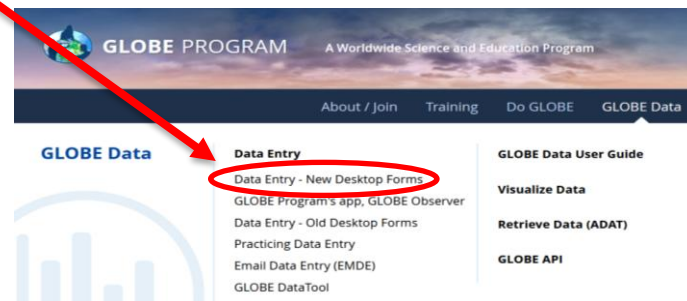
These methods all allow users to submit environmental data – collected at defined sites, according to protocol, and using approved instrumentation – for entry into the official GLOBE science database.

1. Download the GLOBE Observer mobile app from the [App Store](#).
2. Data Entry: Visit [globe.gov](http://globe.gov), click on the “GLOBE Data” tab, then underneath “Data Entry” click on “Data Entry – New Desktop Forms”.



*Note 1: You will need a GLOBE teacher, trainer, or scientist account to submit GLOBE data.*

*Note 2: It may take some time after you enter your data for it to appear in the GLOBE data visualization system.*





Atmosphere

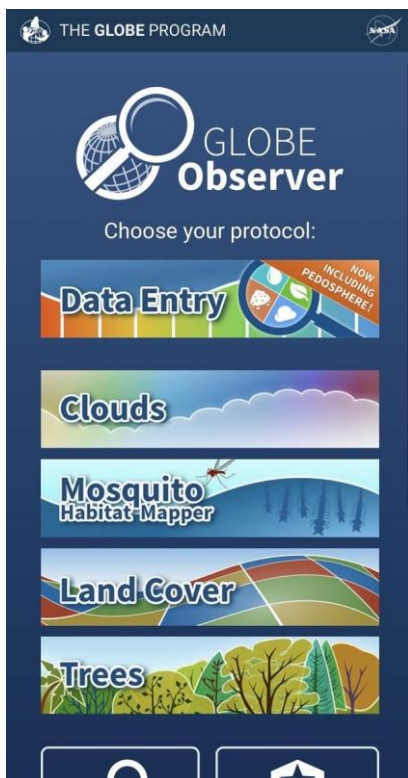


Aerosols

# Entering Aerosol Data – Step 1&2

The steps below will walk you through entering your Atmosphere Study Site Information in the GLOBE Observer App, which you can access using your GLOBE or GLOBE Observer login.

1. Click "Data Entry"



2. Click "Create/Edit My Sites"



A. What are aerosols?

B. Why collect aerosol data?

C. How your measurements can help!

D. How to collect your data.

**E. How to report your data to GLOBE.**

F. Understand the data.

G. Quiz yourself!

H. Further resources.



# Entering Aerosol Data – Step 3

3. Click on the arrow next to "Atmosphere" and select "Aerosols".  
The other necessary protocols will be automatically selected.

Select Protocols

▼ Atmosphere	3
<input checked="" type="checkbox"/> Aerosols	
<input type="checkbox"/> Air Temperature	
<input checked="" type="checkbox"/> Barometric Pressure *	
<input checked="" type="checkbox"/> Clouds *	
<input type="checkbox"/> Precipitation	
<input type="checkbox"/> Relative Humidity	
<input type="checkbox"/> Surface Temperature	
<input type="checkbox"/> Water Vapor	
<input type="checkbox"/> Wind	
* Required for one or more selected protocols	
► Biosphere	0
► Hydrosphere	0
► Pedosphere	0

Home, List, Help, Home icons at the bottom.

A. What are aerosols?

B. Why collect aerosol data?

C. How your measurements can help!

D. How to collect your data.

**E. How to report your data to GLOBE.**

F. Understand the data.

G. Quiz yourself!

H. Further resources.



# Entering Aerosol Data – Step 4&5

A. What are aerosols?

B. Why collect aerosol data?

C. How your measurements can help!

D. How to collect your data.

**E. How to report your data to GLOBE.**

F. Understand the data.

G. Quiz yourself!

H. Further resources.

4. At the bottom of the screen, click “Continue”. When prompted, enter site location details (latitude, longitude, and elevation). Choose an existing site or identify a new site by clicking “+ New Site Location”

Site Location

Select your site from this list of sites shown on the map:

Select from all available sites. Narrow the list by typing into the search field.

Search Site Names

Show ten more

+ New Site Location

5. Check to see if the “*Date and Time*” are correct, if it is not, click “*Get Current Time*” to update it. Then click “*Clouds*” to move on

< Date and Time

Enter the local date and time of the observation:

Local Date: 2025-11-12

Local Time (24hr): 03:03:00

Get Current Time

Observation Date: 2025-11-12 UTC

Observation Time: 08:03 UTC

Solar Noon: 16:39 UTC

Clouds






# Entering Aerosol Data – Step 6


6. Click the “*Cloud Coverage*” level that best describes your current observation

< Cloud Coverage

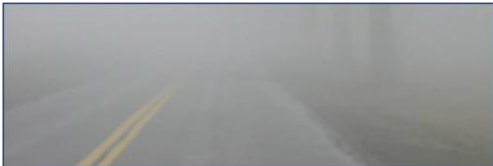
What does your sky look like?



Clouds or Contrails>



Clear Sky  
(No Clouds or Contrails)>



Obscured  
(smoke, dust, haze, fog, etc. limits view of sky)>

A. What are aerosols?

B. Why collect aerosol data?

C. How your measurements can help!

D. How to collect your data.

**E. How to report your data to GLOBE.**

F. Understand the data.

G. Quiz yourself!

H. Further resources.



# Entering Aerosol Data – Step 7

7a. Click on the “*Overall Sky Conditions*” options that best describe your current “*Cloud Coverage*”. There will be multiple sections to scroll through and select choices in. Below are the options that appear if you selected “***Clouds or Contrails***” before

< Overall Sky Conditions

What percentage of the whole sky is covered by clouds? \*

Few < 10 ☐

Isolated 10 - 25 ☐

Scattered 25 - 50 ☐

Broken 50 - 90 ☐

Overcast 90 - 100 ☐

What color is the deepest shade of blue in the sky?

Deep Blue ☐

Blue ☐

Light Blue ☐

Pale Blue ☐

Milky ☐

What is the sky visibility across the horizon?

Unusually Clear ☐

Clear ☐

Somewhat Hazy ☐

Very Hazy ☐

Extremely Hazy ☐



- A. What are aerosols?
- B. Why collect aerosol data?
- C. How your measurements can help!
- D. How to collect your data.
- E. How to report your data to GLOBE.**
- F. Understand the data.
- G. Quiz yourself!
- H. Further resources.



- A. What are aerosols?
- B. Why collect aerosol data?
- C. How your measurements can help!
- D. How to collect your data.
- E. How to report your data to GLOBE.**
- F. Understand the data.
- G. Quiz yourself!
- H. Further resources.

## Entering Aerosol Data – Step 7

7a.i “**Clouds or Contrails**” continued: After selecting “Overall Sky Conditions” you will see a screen asking you identify the cloud types. If you already know how to identify clouds, you may proceed to “*Manual Cloud Identification*”, otherwise, click on “*Guided Cloud Identification Wizard*” for a briefing on cloud identification



Choose Mode

If you are comfortable identifying clouds by type at different heights, choose Manual Cloud Identification.

---

**Manual Cloud Identification**



**Guided Cloud Identification Wizard**





# Entering Aerosol Data – Step 7

A. What are aerosols?

B. Why collect aerosol data?

C. How your measurements can help!

D. How to collect your data.

**E. How to report your data to GLOBE.**

F. Understand the data.

G. Quiz yourself!

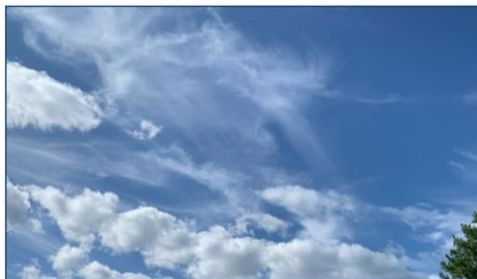
H. Further resources.

7a.i “**Clouds or Contrails**” continued: The *Guided Cloud Identification Wizard* will remind you identify all the different cloud types before showing you the “*Cloud Triangle*” that you will reference to determine cloud height. It also shows the types of clouds likely to appear at certain altitudes.



[Skip Wizard Introduction](#) >

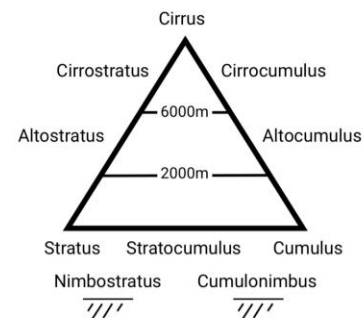
The Cloud Wizard will help you identify cloud types by looking at cloud shape and height. Remember to identify all the different cloud types in your sky.



Next



The Cloud Triangle is a useful tool for determining cloud altitude or "level".



We will use the Cloud Triangle as a quick reference for clouds at each level.



High Level Clouds



Mid Level Clouds



Low Level Clouds





# Entering Aerosol Data – Step 7

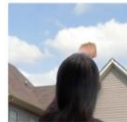
7a.i “**Clouds or Contrails**” continued: The *Guided Cloud Identification Wizard* will list the way to identify clouds based on how they look. You can select multiple cloud shapes. Afterwards, you will be given the option to identify cloud coverage and opacity for each of the different levels of the *Cloud Triangle* by pressing “Observe”. This is not necessary to move forward with submitting the observation



When using the wizard, we'll ask you to identify clouds based on how they look:

"Puffy"

Low



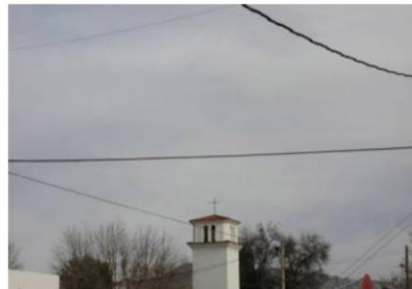
Medium



High



"Layered"



"Wispy"

"Wispy"



Checks will indicate which clouds you've identified.

It's possible to select more than one cloud shape. You might see puffy, layered and wispy clouds all at the same time!



After identifying cloud types, you will be given the option to identify percent cloud coverage and opacity for each of the different cloud levels (low, medium and high). Press the 'Observe' button to do so. This is optional.



Observe

Overall Cloud Cover:\*  
Not Set

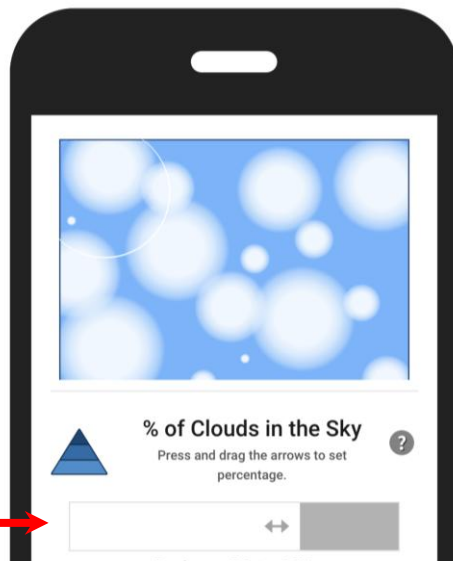


- A. What are aerosols?
- B. Why collect aerosol data?
- C. How your measurements can help!
- D. How to collect your data.
- E. How to report your data to GLOBE.**
- F. Understand the data.
- G. Quiz yourself!
- H. Further resources.



# Entering Aerosol Data – Step 7

7a.i “**Clouds or Contrails**” **continued**: To identify cloud coverage and opacity percentage, you must press and move the arrows to change the percentages. The images will give you a visual sense of what the percentage ranges represent. When you’re done, send your data to GLOBE!



Next

When you’re done send your data to GLOBE!



Let's Get Started!


- A. What are aerosols?
- B. Why collect aerosol data?
- C. How your measurements can help!
- D. How to collect your data.
- E. How to report your data to GLOBE.**
- F. Understand the data.
- G. Quiz yourself!
- H. Further resources.




# Entering Aerosol Data – Step 7


7a.ii “**Clouds or Contrails**” continued: After completing the *Guided Cloud Identification Wizard*, you will have to select the number and type of contrails you observe.


< Types of Contrails

 **Contrails**  
High Level  
[Learn About This Cloud](#) <

Choose the number of contrail types seen:

  
Short Lived  
- 0 +

  
Persistent Non Spreading  
- 0 +

  
Persistent Spreading  
- 0 +

[Skip Contrails](#) >

[No Contrails Visible](#) >

- A. What are aerosols?
- B. Why collect aerosol data?
- C. How your measurements can help!
- D. How to collect your data.
- E. How to report your data to GLOBE.**
- F. Understand the data.
- G. Quiz yourself!
- H. Further resources.



# Entering Aerosol Data – Step 7

7a.ii “**Clouds or Contrails**” continued: Please select either “No” or “Yes” depending on if the cloud’s appearance matches the one being described for rain clouds.



Is there thunder, lightning and/or heavy rain?



No

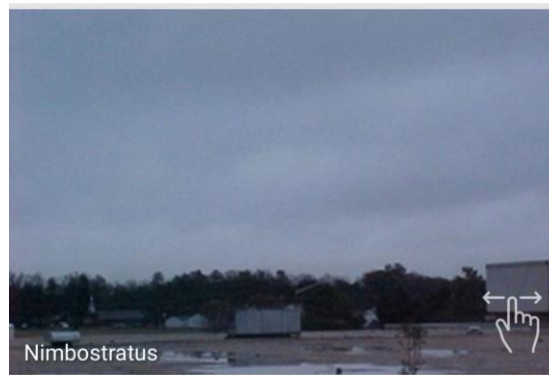
0 Clouds  
Identified

Done

Yes



Is it only drizzly with small raindrops?



No

0 Clouds  
Identified

Done

Yes

- A. What are aerosols?
- B. Why collect aerosol data?
- C. How your measurements can help!
- D. How to collect your data.
- E. How to report your data to GLOBE.
- F. Understand the data.
- G. Quiz yourself!
- H. Further resources.



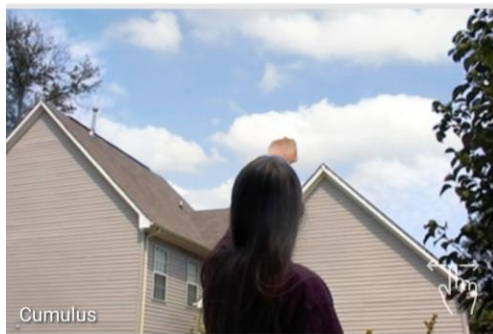


# Entering Aerosol Data – Step 7

7a.ii “**Clouds or Contrails**” continued: Please select either “No” or “Yes” depending on if the cloud’s appearance matches the one being described for puffy clouds.



< Holding your hand out to the sky, are there puffy clouds about fist size? >



No 0 Clouds Identified Done Yes



< Holding your hand out to the sky, are there puffy clouds about thumb size? >



No 0 Clouds Identified Done Yes



< Holding your hand out to the sky, are there puffy clouds about pinky size? >



No 0 Clouds Identified Done Yes

- A. What are aerosols?
- B. Why collect aerosol data?
- C. How your measurements can help!
- D. How to collect your data.
- E. How to report your data to GLOBE.
- F. Understand the data.
- G. Quiz yourself!
- H. Further resources.



# Entering Aerosol Data – Step 7

7a.ii “**Clouds or Contrails**” continued: Please select either “No” or “Yes” depending on if the cloud’s appearance matches the one being described for layered clouds.



< Do you see uniform clouds that often cover the entire sky with no Sun? >



Stratocumulus

No

0 Clouds Identified  
Done

Yes



< Is the Sun dim in a gray sky? >



Altostratus

No

0 Clouds Identified  
Done

Yes



< Is the sky light with a halo around the Sun? >



Cirrostratus

No

0 Clouds Identified  
Done

Yes

- A. What are aerosols?
- B. Why collect aerosol data?
- C. How your measurements can help!
- D. How to collect your data.
- E. How to report your data to GLOBE.
- F. Understand the data.
- G. Quiz yourself!
- H. Further resources.



# Entering Aerosol Data – Step 7

7a.ii “**Clouds or Contrails**” continued: Please select either “No” or “Yes” depending on if the cloud’s appearance matches the one being described for wispy clouds. After this, you will have completed the cloud identification and will be taken to a review of your identified clouds.

Are there white wispy (Cirrus) clouds that look like white delicate feathers?

Cirrus

No 0 Clouds Identified Done Yes

Are there white wispy (Cirrus) clouds that look like white delicate feathers?

Cirrus

**Wizard Completed!**  
Would you like to return to the wizard, or are you done identifying clouds?

Return Done

No 0 Clouds Identified Done Yes

- A. What are aerosols?
- B. Why collect aerosol data?
- C. How your measurements can help!
- D. How to collect your data.
- E. How to report your data to GLOBE.**
- F. Understand the data.
- G. Quiz yourself!
- H. Further resources.





# Entering Aerosol Data – Step 7

7a.ii “**Clouds or Contrails**” continued: After completing the visual identification, you will be asked to observe *Cloud Cover* and *Visual Opacity*. After learning how to observe both, you will be instructed to make observations for the clouds that you identified previously.

< Cover And Opacity Summary

---

How to observe Cloud Cover

---

How to observe Visual Opacity

---

Tap 'Observe' to learn to accurately observe Cloud Cover or Visual Opacity

Overall Cloud Cover:\*  
Few 0 - 10%

Observe

---

High Cloud Cover:  
Not Set

Observe

High Visual Opacity:  
Not Set

Clouds: Contrails

---

No Mid Level Clouds Identified

Observe

< Measuring Cloud Cover

---

How to Observe: Cloud Cover

When estimating cloud cover, we should NOT consider clouds far away or at the horizon. Estimate the cloud cover by observing the sky above 14 degrees.

Hold your fist out at arm's length, even with the horizon. Observe the sky above the height of three fists.

Back

< Measuring Visual Opacity

---

How To Observe Visual Opacity

---

**Transparent**  
Thin clouds through which light passes easily, and through which you can even see blue sky. Note the milky bluish-whitish appearance.

---

**Translucent**  
Medium-thickness clouds that let some sunlight through. There may be some milky bluish-white near the edges, and a very little bit of gray; but these clouds are mostly a bright white.

---

**Opaque**  
Thick clouds which do not allow light to pass directly, although light can diffuse through them. Clouds look gray. When these clouds are in front of the Sun, it is impossible to tell where the Sun is.

< Cover And Opacity Summary

---

How to observe Cloud Cover

---

How to observe Visual Opacity

Tap 'Observe' for a tool to help record your observations

Overall Cloud Cover:\*  
Few 0 - 10%

Observe

---

High Cloud Cover:  
Not Set

Observe

High Visual Opacity:  
Not Set

Clouds: Contrails

---

No Mid Level Clouds Identified

Observe





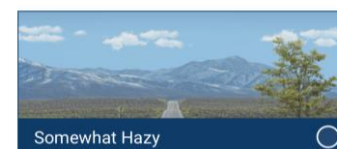
# Entering Aerosol Data – Step 7

7b. Click on the “*Overall Sky Conditions*” options that best describe your current “*Cloud Coverage*”. There will be multiple sections to scroll through and select choices in. Below are the options that appear if you selected “***Clear Sky***” before

What color is the deepest shade of blue in the sky?



What is the sky visibility across the horizon?



- A. What are aerosols?
- B. Why collect aerosol data?
- C. How your measurements can help!
- D. How to collect your data.
- E. How to report your data to GLOBE.**
- F. Understand the data.
- G. Quiz yourself!
- H. Further resources.



# Entering Aerosol Data – Step 7

A. What are aerosols?

B. Why collect aerosol data?

C. How your measurements can help!

D. How to collect your data.

**E. How to report your data to GLOBE.**

F. Understand the data.

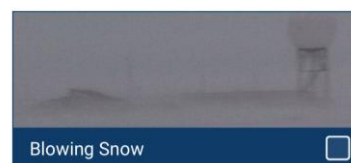
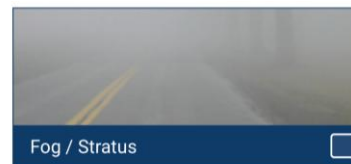
G. Quiz yourself!

H. Further resources.

7c. Click on the “*Overall Sky Conditions*” options that best describe your current “*Cloud Coverage*”. There will one section with multiple sections. Below are the options that appear if you selected “**Obscured**” before

## < Types of Obscurations

Click on the types of obscurations:







# Entering Aerosol Data – Step 8

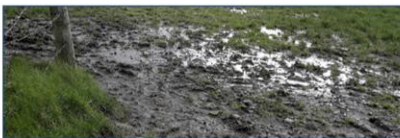
8. After completing your observations of clouds, select “Yes” or “No” on the various available surface conditions that appear during your observation. At the bottom, click the “Next” button to move on

< Surface Conditions


Select Yes or No for each of the following surface conditions: \*


  
Snow / Ice


  
Standing Water

  
Muddy

< Surface Conditions

  
Dry Ground

  
Leaves on Trees

  
Raining / Snowing

A. What are aerosols?

B. Why collect aerosol data?

C. How your measurements can help!

D. How to collect your data.

**E. How to report your data to GLOBE.**

F. Understand the data.

G. Quiz yourself!

H. Further resources.



# Entering Aerosol Data – Step 9

9. If your photometer measures AOT directly, click “Yes” and select your photometer model (Either Shade, Calitoo, or Other). If it doesn’t, click “No” and enter your photometer serial number. After, click “*Check Photometer*” at the bottom

< Aerosols

Does your photometer measure AOT directly?

☒ Yes

☐ No

Photometer Serial Number:

Photometer Model: \*

Check Photometer

Shade

Calitoo

Other

< Aerosols

Does your photometer measure AOT directly?

☐ Yes

☒ No

Photometer Serial Number: \*

Photometer Model: \*

Check Photometer





# Entering Aerosol Data – Step 10&11

A. What are aerosols?

B. Why collect aerosol data?

C. How your measurements can help!

D. How to collect your data.

**E. How to report your data to GLOBE.**

F. Understand the data.

G. Quiz yourself!

H. Further resources.

10. If you have information on a satellite overflight occurring during your observation date, click “Yes” and enter satellite/instrument name, the overflight time, and the maximum elevation angle. Otherwise, click “No” and proceed to enter the wavelength and AOT readings for your trials/samples. At the bottom, click the “*Barometric Pressure*” button when finished

11. Enter Barometric Pressure type and measurement details. Then click “*Review*” to view your observation summary, and then click “*Finish*” to submit the observation

< Aerosols

Do you know when there was a satellite overflight on date of measurement? \*

☐ Yes

☐ No

Green Channel -Sample#1

Local Time (24hr): \*

03:12:01

Wavelength (nm): \*

AOT Reading: \*

< Barometric Pressure

Select Type and Enter Measurement

☐ Sea Level

☐ Station Pressure

Pressure (mb): \*

Comments:

Review

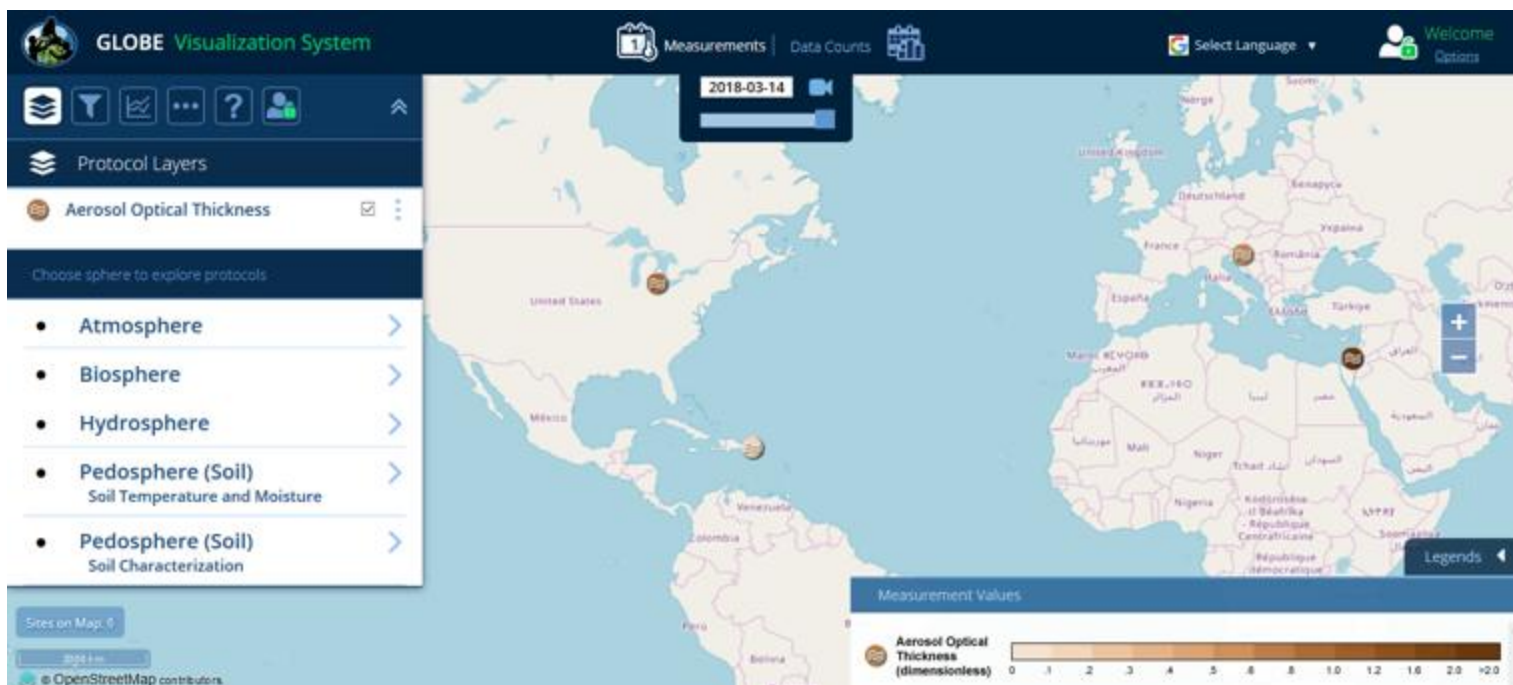
Skip & Review



# Visualize and Retrieve Data

GLOBE provides the ability to view and interact with data measured across the world. Select our [visualization tool](#) to map, graph, filter and export data that have been measured across GLOBE protocols since 1995.

These step-by-step tutorials on using the visualization system will assist you in finding and analyzing data: [PDF version](#) [PowerPoint version](#)



<http://vis.globe.gov/GLOBE/>



# Visualize and Retrieve Data – Step 2

Select the date for which you need data, add the protocol layers, and you can see where data is available.

The screenshot displays the GLOBE Visualization System interface. On the left, a sidebar contains a 'Protocol Layers' section with a list of protocols. A red arrow points to the 'Aerosols' protocol, which is expanded to show 'Aerosol Optical Thickness' (checked) and 'Percent Transmission' (unchecked). Another red arrow points to the 'Date' selector in the top right, which is set to '2025-11-14'. The main area shows a map of North America with data points visible.

**GLOBE Visualization System**

Measurements | Data Counts

2025-11-14

Protocol Layers

Choose a Sphere below to see protocols. From there, open each protocol to see the available data layers that can be added to the map.

< Check to select Protocols **SUBMIT**

- Air Temperature Dailies
- Air Temperature Monthlies
- Air Temperature Noons
- Air Temperature
- Aerosols**
  - ☒ Aerosol Optical Thickness
  - ☐ Percent Transmission

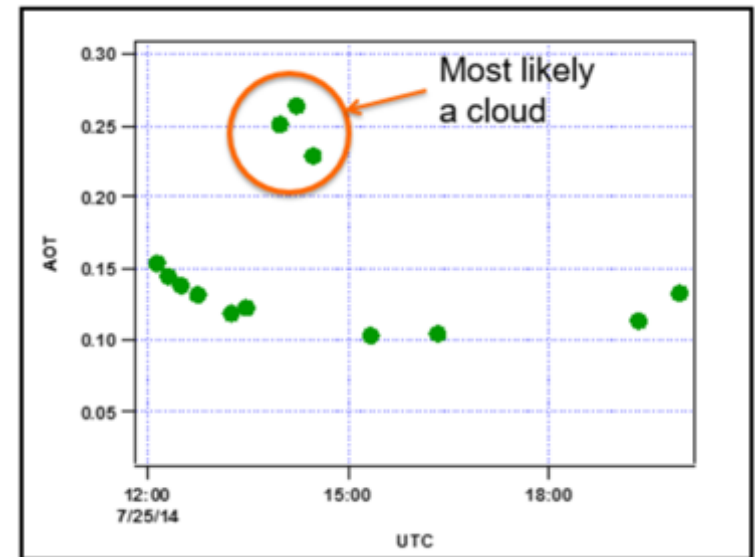
- A. What are aerosols?
- B. Why collect aerosol data?
- C. How your measurements can help!
- D. How to collect your data.
- E. How to report your data to GLOBE.
- F. Understand the data.**
- G. Quiz yourself!
- H. Further resources.



# Measurement Tips

You will be able to tell when a cloud moves across the Sun, interrupting your measurement. There will be a sudden, sometimes dramatic change in your raw signal, even if the cloud is a very thin cirrus cloud that is difficult to see with your eyes.

- When using a GLOBE Sun photometer, the voltage will decrease (AOT calculated on the GLOBE site would go up).
- When using a Calitoo, the raw signal displayed during measurement will decrease, which will be translated by the instrument as a higher AOT value once the measurement is finalized.



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# Graphing Your Measurements

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C. How your measurements can help!

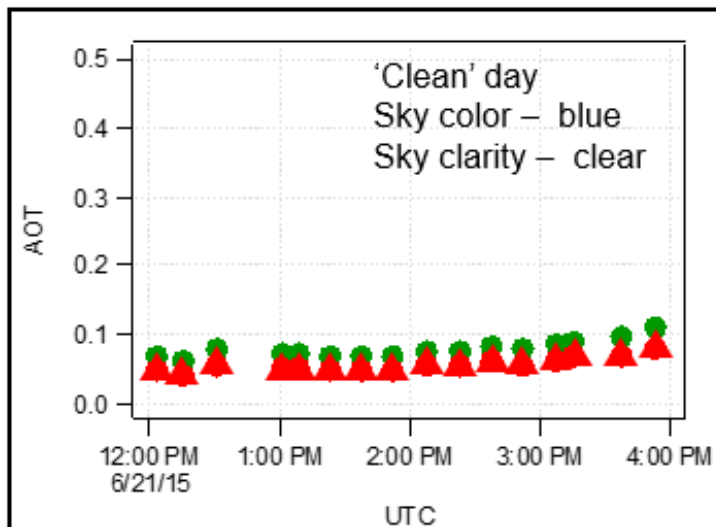
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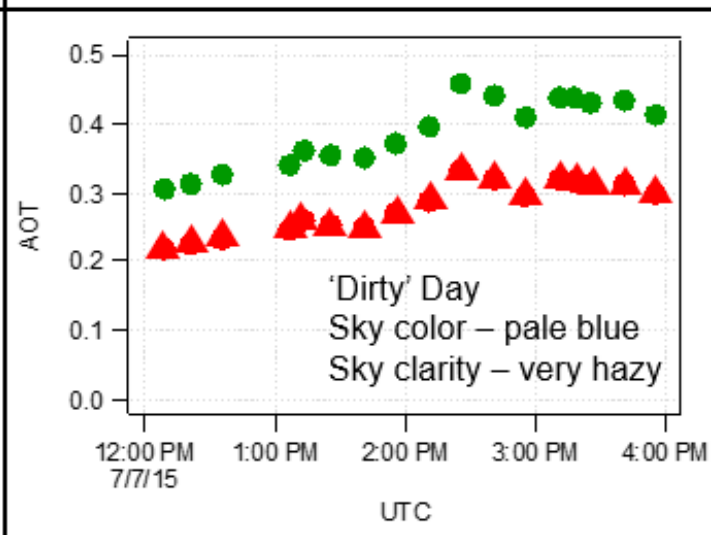
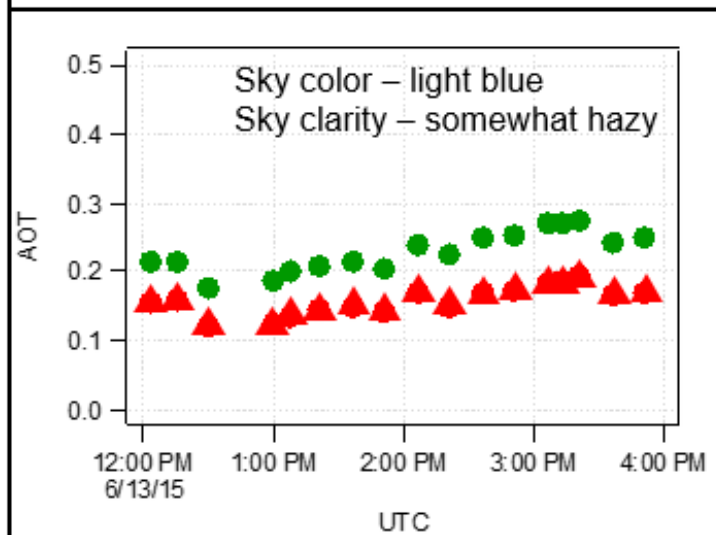
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If you make measurements throughout the day, you can observe how aerosol concentrations change.

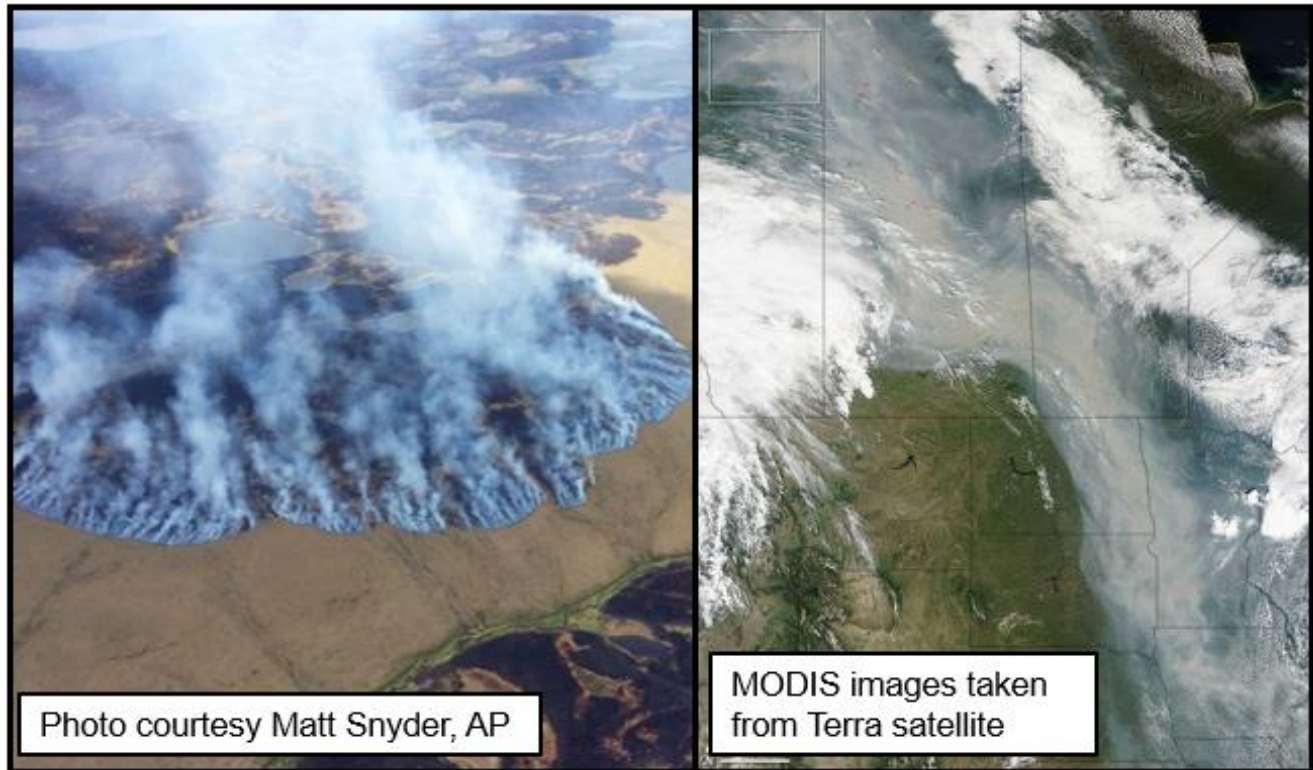
These measurements were made with a GLOBE Sun photometer. The green and red markers correspond to the two measurement wavelengths available on a GLOBE Sun photometer.





# By Graphing Your Measurements You Might Observe Major Aerosol Plumes

In June of 2015, a series of wildfires in the plains of Canada sent huge plumes of smoke east over the Midwest and East coastal regions of the United States. These fires burned for weeks, sending “rivers of smoke” across the continent. Scientists could even see the smoke from space!



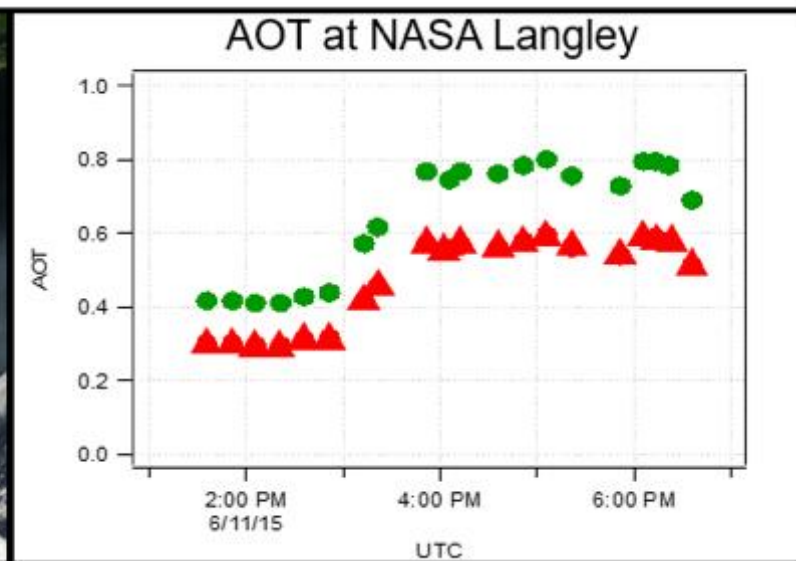
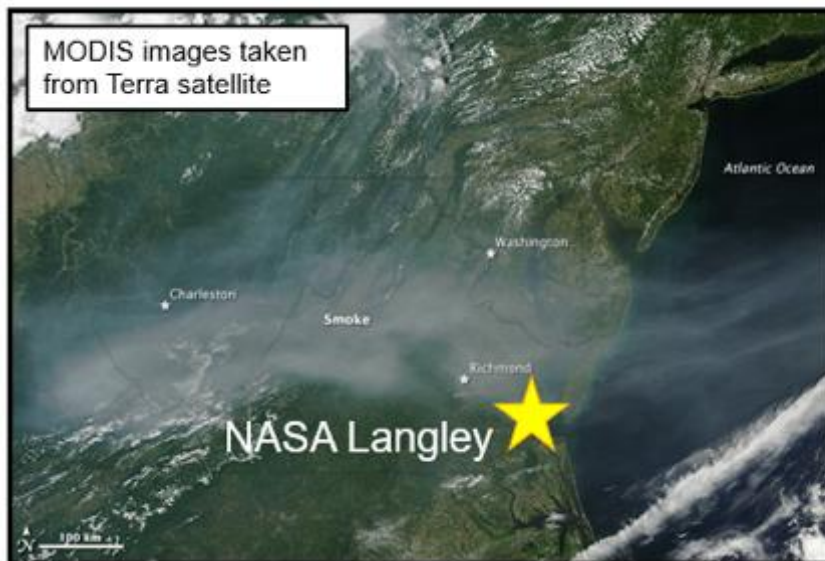
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## By Graphing Your Measurements You Might Observe Major Aerosol Plumes (1)

Thousands of kilometers away at NASA Langley, GLOBE scientists measuring aerosols using a Sun photometer saw substantially increased AOT values. They also observed that the sky was extremely hazy and milky in color— air pollution in action!







# By Graphing Your Measurements You Might Observe Major Aerosol Plumes (2)

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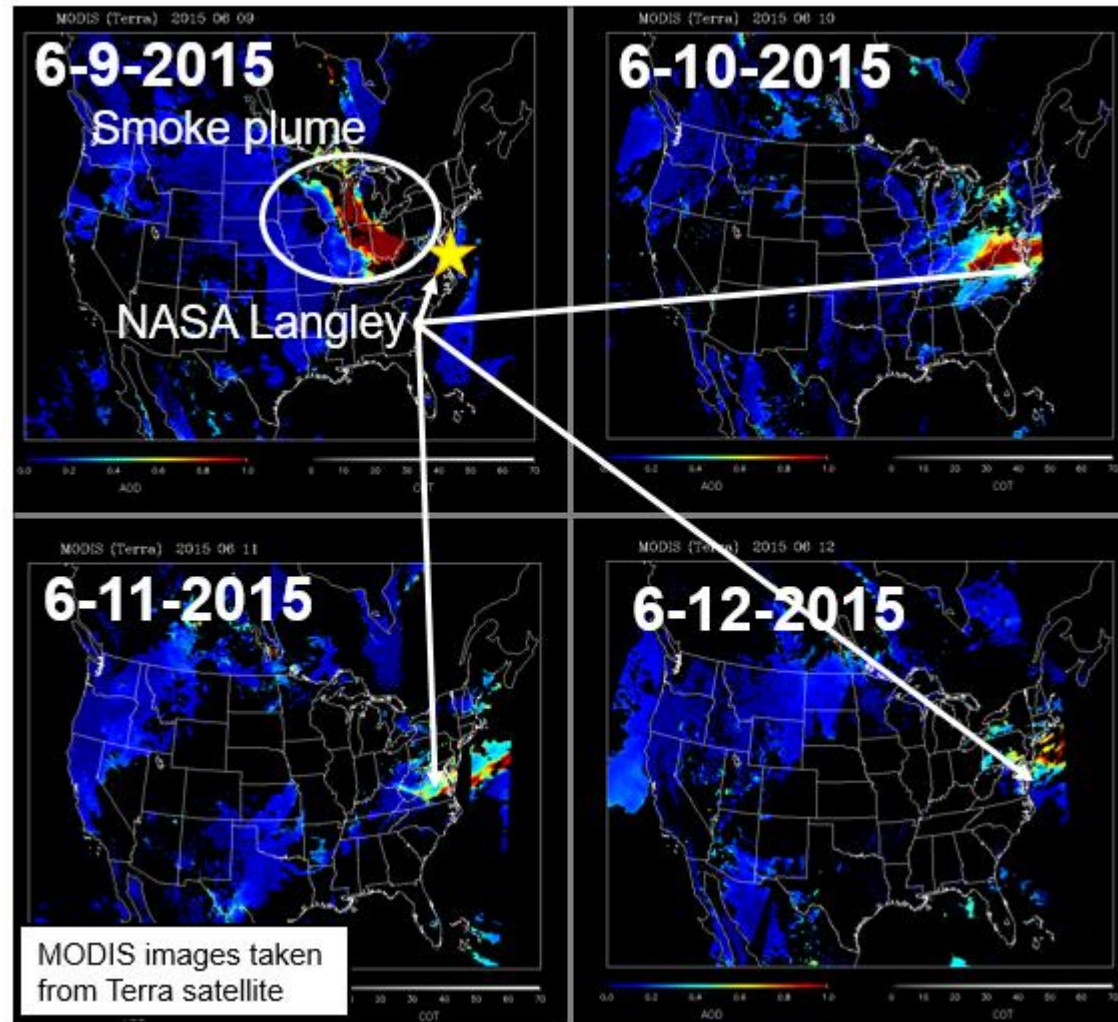
E. How to report your data to GLOBE.

**F. Understand the data.**

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When scientists compared their Sun photometer AOT measurements with AOT taken from satellites, they saw that the smoke plume was in fact the cause of the elevated readings!







# Aerosols: Local Phenomena, Global Impact

Aerosols come from many sources, both natural and man-made, and have an important role to play in global climate, air quality, and environmental health. GLOBE aerosol measurements help scientists learn more about the origins of particles in our atmosphere as well as determine where these global travelers go before falling back to the Earth's surface.

By participating in GLOBE aerosol measurement studies, you are helping to tell the stories of local atmospheric phenomena that can have global impacts. You are helping scientists find answers to the question: what *is* up in the atmosphere?


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## Quiz Questions

Challenge yourself to answer these questions and check whether you have achieved the learning objectives of this module.

1. [What are aerosols?](#)
2. What [processes](#) contribute to the formation of aerosols?
3. What is [aerosol optical thickness \(AOT\)](#) and how does it relate to the quantity of aerosols in the atmosphere?
4. What [parameters](#) measured in other GLOBE protocols are important to consider when making aerosol measurements?
5. What kinds of effects do aerosols have on [global climate](#)?
6. What kinds of effects do aerosols have on [local atmospheric phenomena](#)?
7. How do different aerosols [affect cloud formation](#)?

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# GLOBE Learning Activities & Resources

The following activities will help you become familiar with the GLOBE Atmosphere materials and the GLOBE data visualization platform.

- [Atmosphere Learning Activities Introduction](#)
- [Observing Visibility and Sky Color](#)
- [Calculating Relative Air Mass](#)
- [Making a Sundial](#)
- [Draw Your Own Visualization](#)
- [Learning to Use Visualizations - An Example with Elevation and Temperature](#)

Questions about this module? Contact GLOBE: [help@nasaglobe.gov](mailto:help@nasaglobe.gov)

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## Credits

### Slides:

Virginia (Jill) Teige, NASA Langley Research Center, USA.

Dr. Margaret Pippin, NASA Langley Research Center, USA.

Jessica Taylor, NASA Langley Research Center, USA.

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### More Information:

[The GLOBE Program](#)

[NASA Wavelength](#) : NASA's Digital Library of Earth and Space Education Resources

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