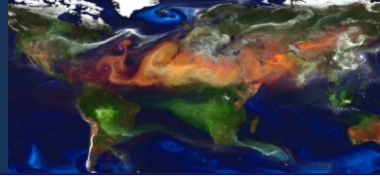




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ATMOSPHERE INVESTIGATION

**Aerosols**



# Aerosol Protocol Training

**Nashville, TN Train-the-Trainer**

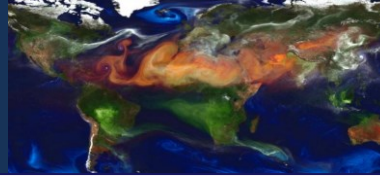
**Lead Trainer: Jessica Taylor [jessica.e.taylor@nasa.gov](mailto:jessica.e.taylor@nasa.gov)**

**Trainers: Sarah McCrea, Preston Lewis, and Tina Harte**



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ATMOSPHERE INVESTIGATION

**Aerosols**



# Aerosols

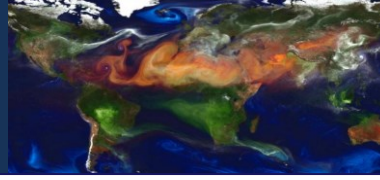


**With every breathe you take, you'll probably inhale millions of solid and liquid particles called Aerosols. Despite their small size, aerosols have a major impact on our climate and health.**



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ATMOSPHERE INVESTIGATION

**Aerosols**

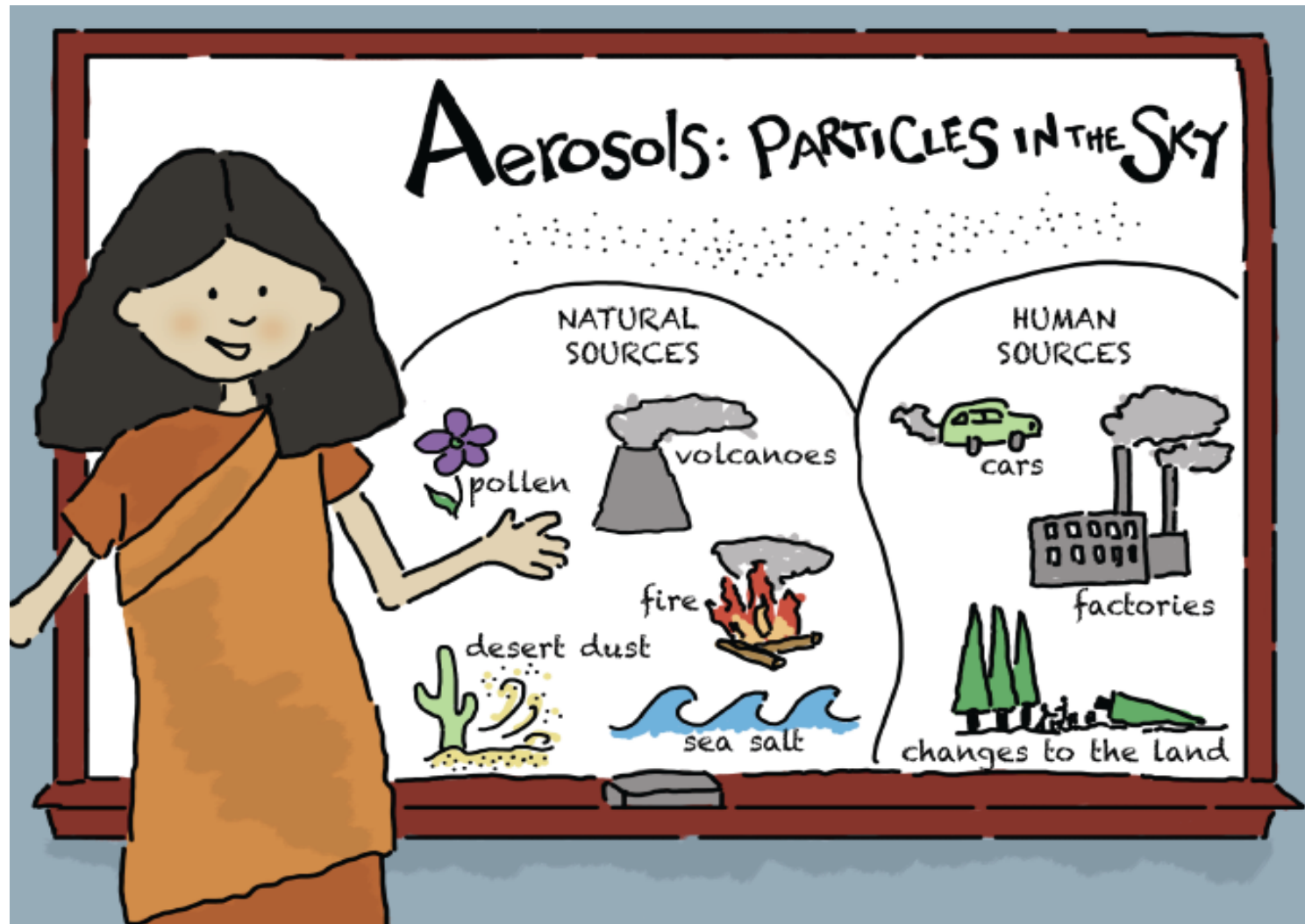


# Before You Begin Aerosols Protocol

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.



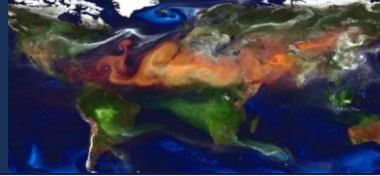
# What are Aerosols?





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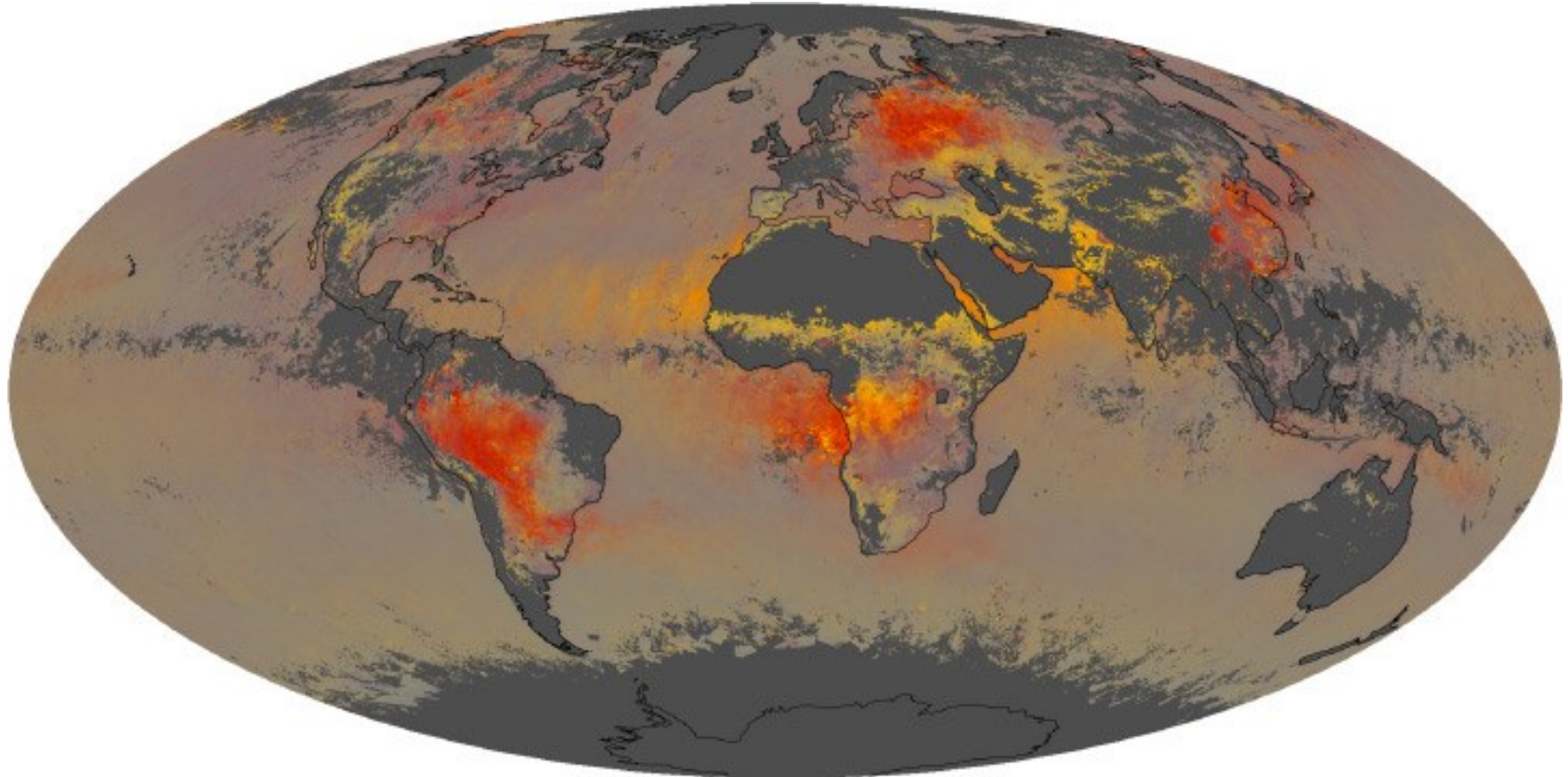


ATMOSPHERE INVESTIGATION

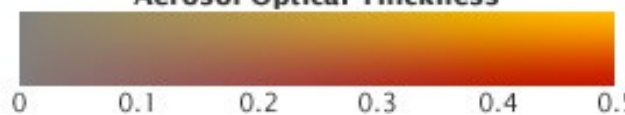
**Aerosols**



# Aerosols Around the Globe



Aerosol Optical Thickness



coarse (i.e. Dust)

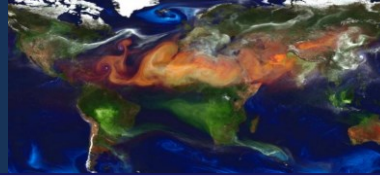
fine (i.e. Smoke or Pollution)

MODIS Image  
From NASA Earth Observatory



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ATMOSPHERE INVESTIGATION

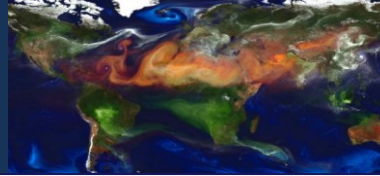
**Aerosols**



# Meet SOL



- [Climate Mission: Secrets of Aerosols and Clouds \(Produced by CNES, French Space Agency\)](#)



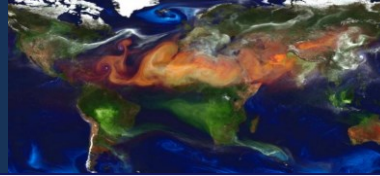
# Aerosols Impact Incoming Sunlight

- Different aerosols scatter or absorb sunlight to varying degrees, depending on their physical properties

## Aerosol's Climate Impacts

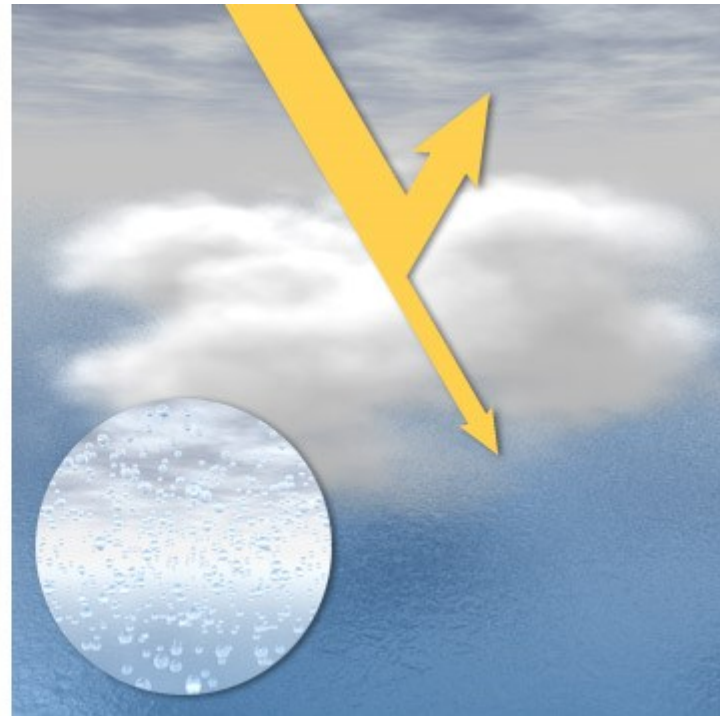
|  |                  |                       |
|--|------------------|-----------------------|
| Smaller Aerosols (ex. sea salt, pure sulfates).              | Reflect Sunlight | <i>Cooling Effect</i> |
| Larger, darker Aerosols (such as soot - carbon from burning) | Absorb Sunlight  | <i>Warming Effect</i> |

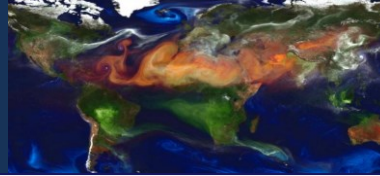




# Aerosol Impact Clouds

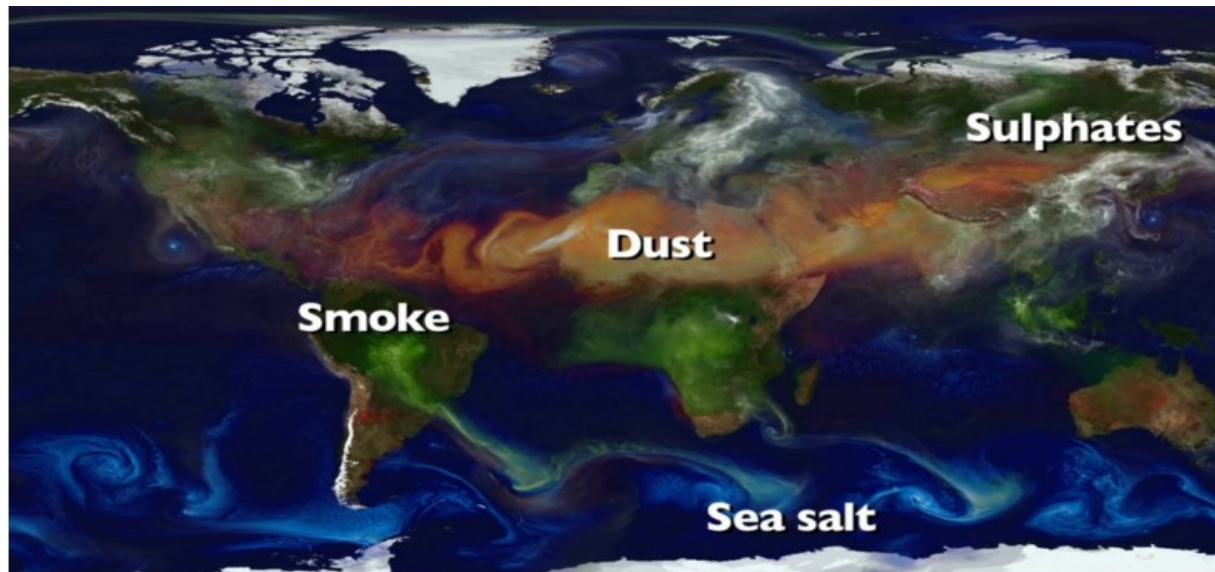
- Aerosols act as cloud condensation nuclei
- More aerosols leads to - more droplets of smaller size - which reflect more sunlight

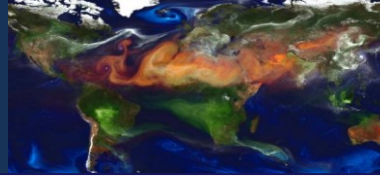




# Aerosols Impact Air Quality

- *These global travelers are linked to adverse health effects.*
- Aerosols impact the quality of the air that we breathe and the health of all living organisms.





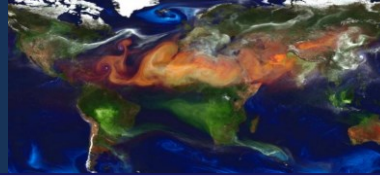
# More Aerosol Research Questions

- *How does black carbon (soot) influence sea ice melt?*
- *How are aerosol concentrations related to the weather and climate?*
- *How long do volcanic aerosols stay in the atmosphere?*
- *How are aerosols changing cloud formation in different regions?*



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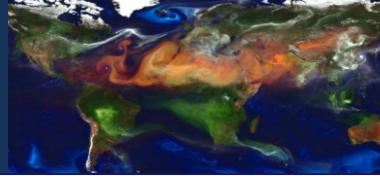
ATMOSPHERE INVESTIGATION

**Aerosols**



# How Measurements of Aerosols Help

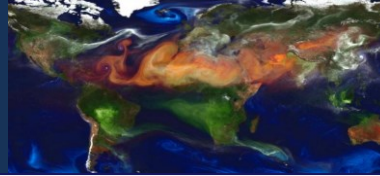
- Improve Air Quality Forecasting
- Improve Climate Forecasting and Understanding



# What Do You Measure?

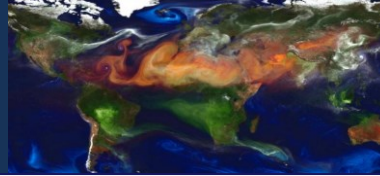
- *Sun photometers tell you how much aerosols there are by measuring sunlight.*
- *Aerosol Optical Thickness (AOT, also called aerosol optical depth) is a measure of how much of the sun's light is scattered or absorbed by particles suspended in the air.*

More Aerosols = Higher AOT = Less Sunlight  
reaching Earth's surface



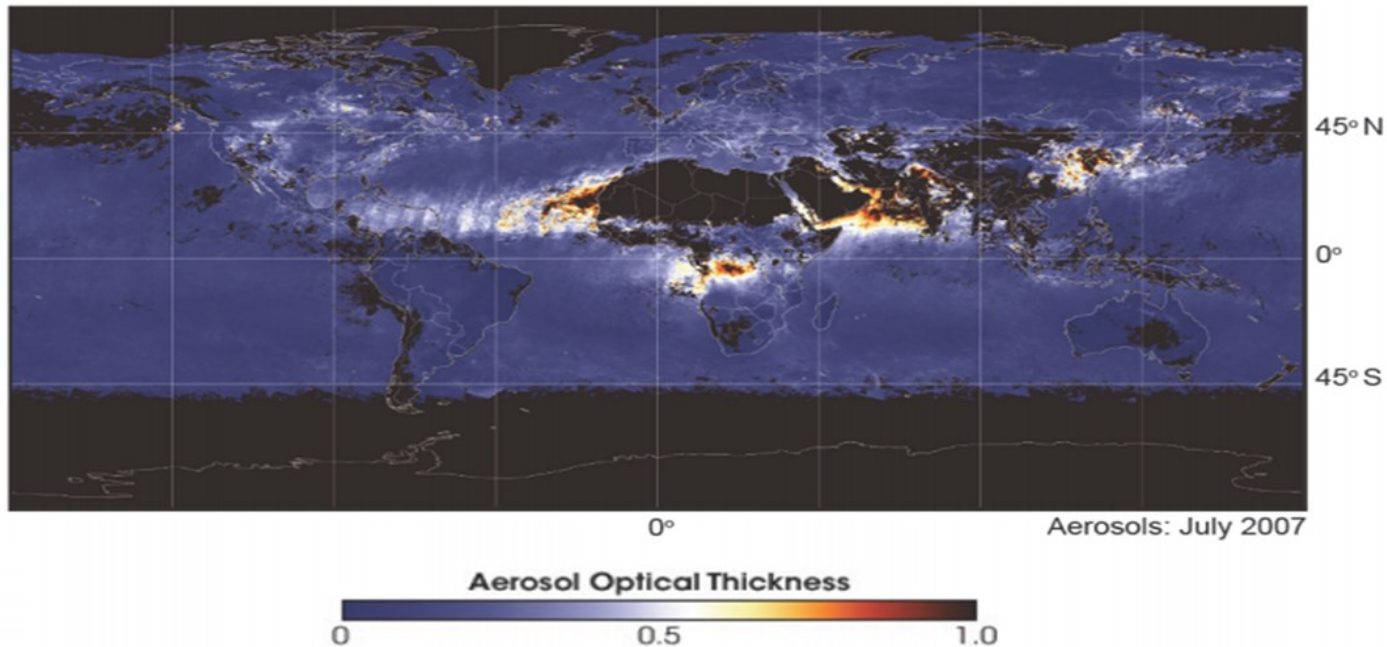
# How Measurement Works

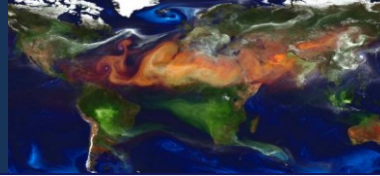
- Sunlight includes a range of wavelengths
- Aerosols and gases absorb and scatter light best at wavelengths that match their size
- Both gases and aerosols absorb and scatter sunlight
- If we know (1) atmospheric pressure, and (2) the elevation angle of the sun, we know the amount of gas between us and the sun
- In the absence of clouds, any light absorption not caused by atmospheric gas is from aerosols



# Values of Aerosol Optical Thickness

- Clear Sky: visible light AOT  $\sim 0.1$
- Very Clear Sky: green light AOT  $\sim 0.05$  or less
- Very Hazy Skies: AOT  $\sim 0.5$  or greater

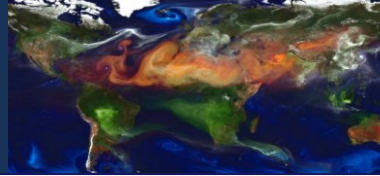




# AOT as Percent Transmission

- This is percentage of light at a particular wavelength that would be transmitted through the atmosphere if the sun were directly overhead.
  - For an optical thickness of 0.10, the percent transmission is about 90.5%.

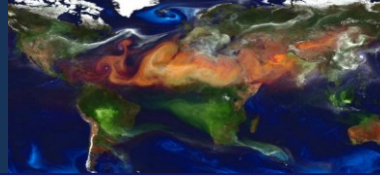
| Optical Thickness | Percent Transmission |
|-------------------|----------------------|
| 0.10              | 90.5%                |
| 0.20              | 81.9%                |
| 0.30              | 74.1%                |
| 0.40              | 67.0%                |
| 0.50              | 60.7%                |
| 0.60              | 54.9%                |
| 0.75              | 47.2%                |
| 1.00              | 36.8%                |
| 1.25              | 28.7%                |
| 1.50              | 22.3%                |
| 2.00              | 13.5%                |
| 2.50              | 8.2%                 |
| 3.00              | 5.0%                 |
| 3.50              | 3.0%                 |
| 4.00              | 1.8%                 |
| 5.00              | 0.7%                 |



# Instrument Options



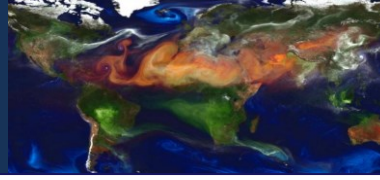
| Brooks GLOBE<br>sun photometer | Calitoo Photometer |
|--------------------------------|--------------------|
| Reads Voltage                  | Reads AOT          |
| “green” 505nm                  | “blue” 465 nm      |
| “red” 625 nm                   | “green” 540 nm     |
|                                | “red” 619 nm       |



# How to Collect: Overview

- **Where?** At your Atmosphere Site
- **When?** Mid-morning, or any other time
- **How?** Using GLOBE Sun-photometer, Calitoo, Shade, or Microtops instruments
- **Notes:** Collect data only when sun is visible
- **Other observations:**
  - Clouds
  - Barometric Pressure
  - Sky Color & Visibility (optional)
  - Current Air temperature (optional)
  - Relative Humidity (optional)

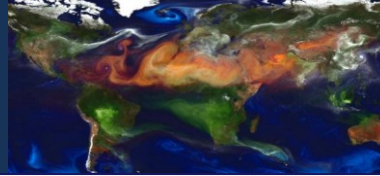




## How to Collect: Using a Calitoo

- Turn On
- Find GPS Signal
- Go To Measuring Mode
- Align dot
- Look for max values
- Record





# How to Collect: Sky Color & Clarity

- Sky Color and sky clarity are optional observations, But these observations should indicate relative amount of aerosols.

Low  
AOT

High  
AOT

## **Sky Color** (Check One):

Deep Blue    Blue    Light Blue    Pale Blue    Milky

## **Sky Clarity** (Check One):

Unusually Clear    Clear    Somewhat Hazy    Very Hazy    Extremely Hazy



# How to Collect: Sky Color

## To Observe Sky Color

- Look in the anti-sun direction (shadow in front of you)
- Observe darkest part of sky, generally half way between horizon and directly overhead
- Categorize the color blue
- Note: if sky color is brown or orange, put in metadata and check obscuration

## Guide to Sky Colors

These colors are intended as an approximate guide to the interpretation of the sky color choices on the data entry form. The appearance of colors on computer monitors varies quite a bit depending on the quality and adjustment of your monitor.

|                         |
|-------------------------|
| deep blue (bleu foncé)  |
| blue (bleu soutenu)     |
| light blue (bleu clair) |
| pale blue (bleu pale)   |
| milky (laiteux)         |



# How to Collect: Sky Clarity

## To Observe Clarity

- Select a distant scene, such as a distant building or a mountain or hillside.
- By looking at the same scene or object every day students will gradually develop a sense of whether the day is unusually clear, clear, somewhat hazy, very hazy, or extremely hazy.





# How to Collect: Prerequisite Data - *Sky Conditions*

- **Mark Sky Conditions**
- If Clouds Visible, ensure there are no clouds covering the sun. Aerosol instrument only work if the sun is unobstructed.
- Never look directly at the sun, even through colored sunglasses or plastic sheets! This can damage your eyes.

**\*Sky Conditions (Check one):**

- Clear (no Clouds Visible)
- Clouds Visible (1% to 100% Covered by Clouds or Contrails)
- Obscured (More than 25% of the Sky is not Visible)

**Note:** selecting *Obscured* will prevent data entry on clouds and contrails; therefore skip the cloud type and cover and the contrail type and cover sections and proceed to the Obscured section. If clouds and contrails are visible in non-obscured areas of the sky, these data can be entered in the Metadata field.






# How to Collect: Prerequisite Data – Clouds



- If Clouds Visible:
- Identify Cloud Type(s)
  - Identify Total Cloud Cover

**If Clouds are Visible select all Cloud Types Seen**




*High (in the sky):*  
(Check all types seen)

|  |   |   |
|--|---|---|
|  |  |  |
| <input type="checkbox"/> Cirrus  | <input type="checkbox"/> Cirrocumulus   | <input type="checkbox"/> Cirrostratus   |



*Middle (of the sky):*  
(Check all types seen)

|  |   |
|--|---|
|  |  |
| <input type="checkbox"/> Altostratus   | <input type="checkbox"/> Altocumulus  |

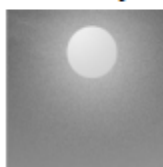
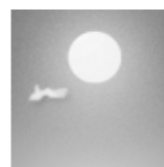
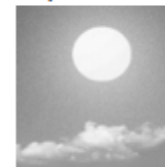
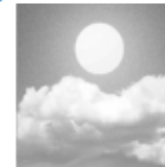


*Low (in the sky):*  
(Check all types seen)

|  |   |   |
|--|---|---|
|  |  |  |
| <input type="checkbox"/> Stratus   | <input type="checkbox"/> Stratocumulus  | <input type="checkbox"/> Cumulus  |

*Rain or Snow Producing Clouds:*  
(Check all types seen)

|   |  |
|---|--|
|  |  |
| <input type="checkbox"/> Nimbostratus   | <input type="checkbox"/> Cumulonimbus  |

**What Percent of the Sky is Covered by Clouds? (Check One) Three-quarters or More of the Sky is Visible: Cloud Cover (Check One)**




|   |   |   |   |   |   |
|---|---|---|---|---|---|
|  |  |  |  |  |  |
| <b>No Clouds</b><br><input type="checkbox"/> 0%                                     | <b>Clear</b><br><input type="checkbox"/> >0 to10%                                   | <b>Isolated</b><br><input type="checkbox"/> 10 to 25%                                 | <b>Scattered</b><br><input type="checkbox"/> 25 to 50%                                | <b>Broken</b><br><input type="checkbox"/> 50 to 90%                                   | <b>Overcast</b><br><input type="checkbox"/> >90%                                      |



# How to Collect: Prerequisite Data – *Contrails*

- Mark Contrail Presence
- Identify and count contrail by type

**Are There Contrails in the Sky?** (Check One)  No Contrails  Contrails are Visible  
**If Contrails are Visible Record the Number of Each Type Seen**

| Short-lived  | Persistent Non-Spreading  | Persistent Spreading   |
|--|---|--|
|  |  |  |
| Number Observed <input type="text"/>   | Number Observed <input type="text"/>  | Number Observed <input type="text"/>   |






**What Percent of the Sky is Covered by Contrails?** (Check one):  
 0 to10%  10 to 25%  25 to 50%  >50%

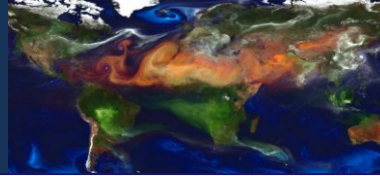


# How to Collect: Prerequisite Data - *Obscuration*

- If Obscured selected, identify obscuration type. Note: Aerosol instrument only work if the sun is unobstructed.
- Never look directly at the sun, even through colored sunglasses or plastic sheets! This can damage your eyes.

***If you Selected Obscured (> 25% of the Sky is not Visible) Check all that apply:***

|   |   |  |   |
|---|---|--|---|
|    |    |    |    |
| <input type="checkbox"/> Blowing Snow   | <input type="checkbox"/> Heavy Snow   | <input type="checkbox"/> Heavy Rain  | <input type="checkbox"/> Fog  |
|  |  |  |  |
| <input type="checkbox"/> Sand   | <input type="checkbox"/> Spray  | <input type="checkbox"/> Volcanic Ash  | <input type="checkbox"/> Smoke  |
|  |  |  |   |
| <input type="checkbox"/> Dust   | <input type="checkbox"/> Haze   |  |   |



# How to Collect: Prerequisite Data – *Other Meteorological Variable*

- Record Barometric Pressure
- Record Current Air Temperature (Optional)
- Record Relative Humidity (Optional)

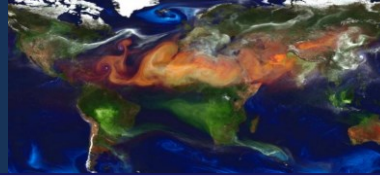
**Air Temperature**  
 Current Temperature (°C): \_\_\_\_\_  
 Comments: \_\_\_\_\_

**Relative Humidity**  
 (Select instrument used):

|   |   |
|---|---|
| <input type="checkbox"/> Sling Psychrometer | <input type="checkbox"/> Digital Hygrometer |
| Dry bulb temperature (°C): _____            | Ambient air temperature (°C): _____         |
| Wet bulb temperature (°C): _____            | Relative Humidity (%): _____                |

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

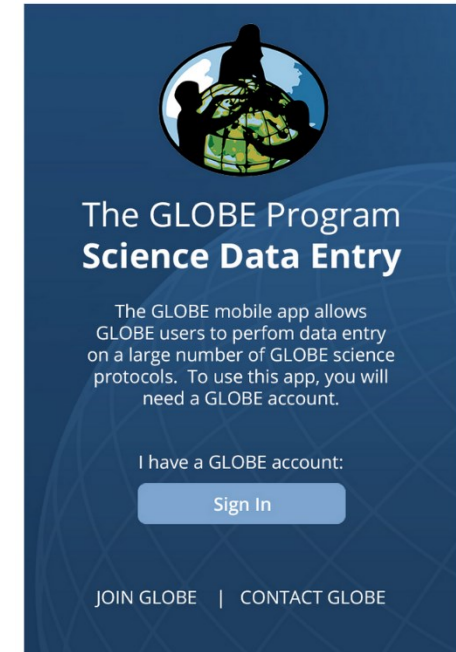
**\*Barometric Pressure**  
 (Check one):  Sea Level Pressure     Station Pressure  
 Pressure (mb): \_\_\_\_\_  
 Comments: \_\_\_\_\_

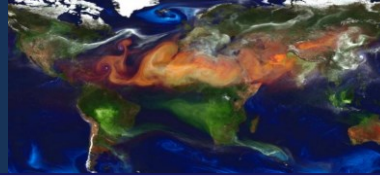


# Upload Data to the Website

## 3 Options for Uploading Data

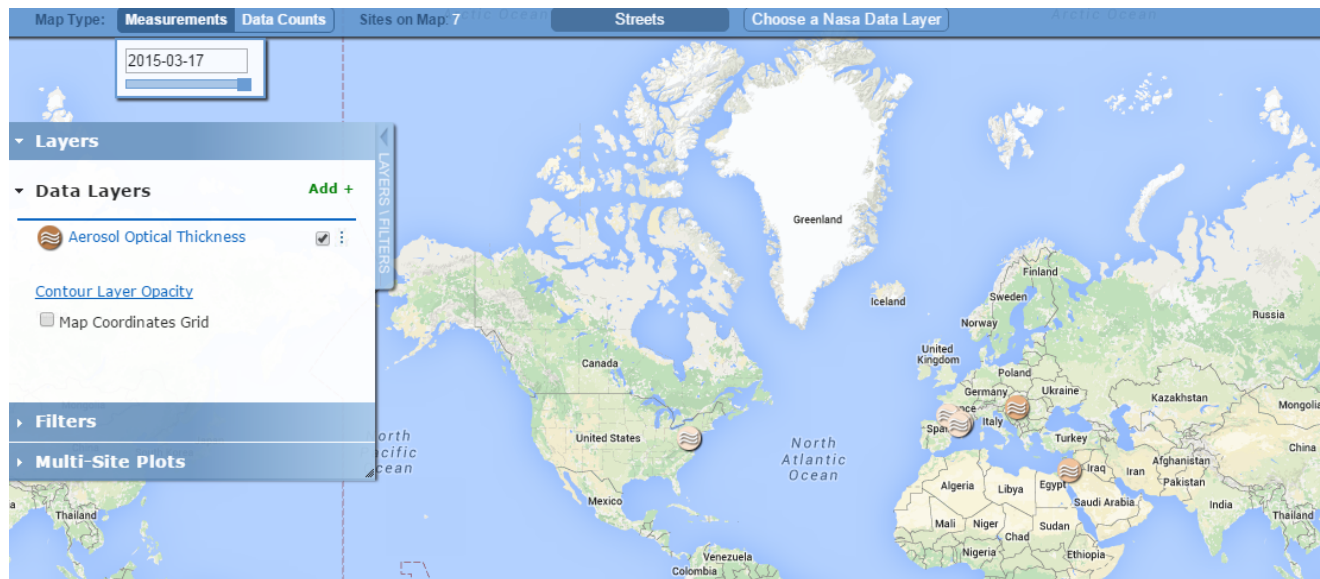
1. Download the app for iOS now from the [App Store](#)
2. [Live Data Entry](#): These pages are for entering environmental data – collected at defined sites, according to protocol, and using approved instrumentation – for entry into the official GLOBE science database.
3. [Email Data Entry](#) – If connectivity is an issue, data can also be entered via email.





## 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 Land Cover Classification data that have been measured across GLOBE protocols since 1995.



Link to step-by-step tutorials on Using the Visualization System will assist you in finding and analyzing GLOBE data:

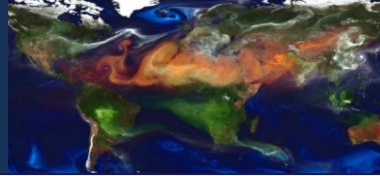
[PDF version](#)

[PowerPoint version](#)



# GLOBE Learning Activities & Resources

- Atmosphere Learning Activities Introduction  
(<http://www.globe.gov/documents/348614/65d837c0-2487-47dc-a789-06f57de1c45e>)
- Observing Visibility and Sky Color  
(<http://www.globe.gov/documents/348614/2c2a13a1-8d97-4f85-a230-4f343bdf9c70>)
- Calculating Relative Air Mass  
(<http://www.globe.gov/documents/348614/b10a107b-3f24-476f-818a-f26835e6e0b7>)
- Making a Sundial  
(<http://www.globe.gov/documents/348614/41018820-9356-4929-a750-11391bf646ae>)
- Draw Your Own Visualization  
(<http://www.globe.gov/documents/348614/ea1af5aa-1082-4014-a287-f44ddea270e7>)
- Learning to Use Visualizations - An Example with Elevation and Temperature  
(<http://www.globe.gov/documents/348614/c5849563-f40b-4e89-9204-a44aa1cacdbe>)

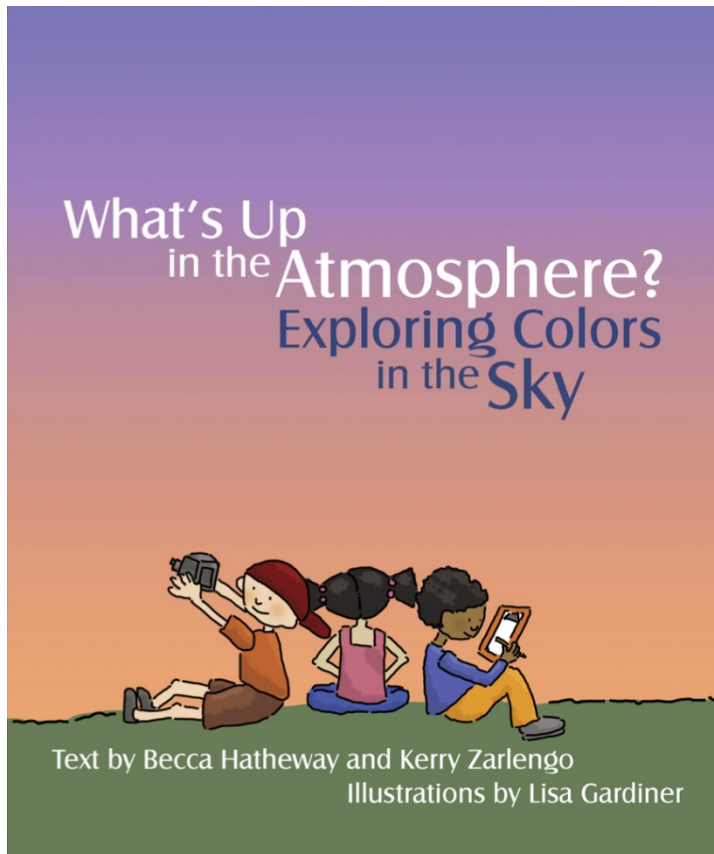


# Elementary GLOBE Aerosols

Try the GLOBE [Aerosols Storybook](#)

And related [Learning Activities](#):

- Sky Observers
- Why (Not) So Blue?
- See The Light
- Up In The Air



Name: \_\_\_\_\_

When I add drops of milk to the water,  
this is what I think will happen:

---

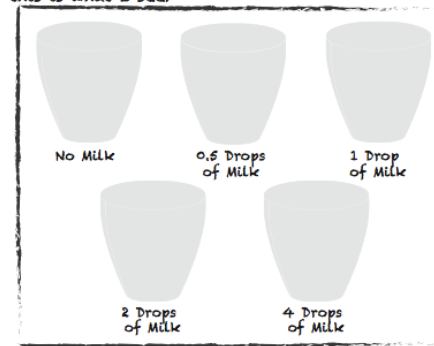


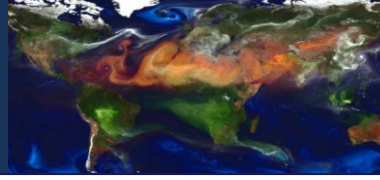
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When I add drops of milk to the water,  
this is what I see:





# Aerosols Field Campaign

- Spring 2016 – Pilot
- Fall 2016 – North America Aerosols Field Campaign
- Interested? Contact Margaret Pippin at NASA Langley [m.pippin@nasa.gov](mailto:m.pippin@nasa.gov)