My NASA Data - Lesson Plans

Tropical Atlantic Aerosols & Clouds

Purpose

Students will use NASA satellite data to determine the location of the greatest concentrations of aerosols during the course of a year in the tropical Atlantic region and their relationship to cloud coverage.

Learning Objectives

- Describe aerosols and their sources in the Earth System
- Analyze aerosols and cloud cover concentrations at different longitudes in the tropical Atlantic over 2015 and 2016
- Develop a claim indicating a perceived relationship of aerosols to cloud cover
- Collect evidence in relation to student’s claim and provide reasoning as to how the evidence
supports the claim

**Essential Questions**

1. What influence do aerosols have on the Earth System?
2. How are clouds and aerosols connected?
3. How do we use data to make and support claims?

**Materials Required**

**Teacher Demonstration:** (optional)
- Map, Atlas or Globe

**Per Student:**
- 1 Copy of the following sheets per student
  - KWL Chart
  - Graphic Organizer
  - Map of Research Area
  - Student Data Sheet
  - C-E-R Rubric (cut in half)
  - Clouds and Aerosols: How much do you know? Quiz (optional)
- Ruler
- Pencil

**Prerequisites Student Knowledge**
- Latitude and longitude
- Line graphs and components of a graph
- Cloud cover % (For a lesson on this topic, see the GLOBE Learning Activity: Estimating Cloud Cover: A Simulation, [https://scool.larc.nasa.gov/lesson_plans/globe-cloudcover.pdf](https://scool.larc.nasa.gov/lesson_plans/globe-cloudcover.pdf))

**Student Misconception**
- Often students have problems with the computation, prediction, and extracting information not explicitly included in the graph.
- New clouds cannot form. Clouds are just pushed from place to place (AAAS Project 2061,
Aerosols are all man-made and bad for the environment.

Procedure

re-Lesson Task:

1. Load the unnarrated version of the 2017 Hurricanes and Aerosols Simulation video.

Part 1: Engage Prior Knowledge of Aerosol Movement in the Atmosphere

1. Tell students that you will show them an unnarrated simulation created by data and computer models. Tell them that there are no labels, dates or indication of color scales.

2. Review the Graphic Organizer with the students to guide their observations:

   Graphic Organizer includes:
   - Topic in the Center: Students write down what they believe is the basis of their observation
   - In the four boxes:
     1. How long do you think this simulation covers (1 day, week, month, season, year/s, decades)? Why?
     2. What do the different colors indicate?
     3. What patterns do you see?
     4. In what ways does the atmosphere connect the continents?
1. Play the video.
2. Students describe their answers.
3. Set the learning intention by telling students that they will be exploring aerosols in the atmosphere and their relationship to weather.

**Part 2: Aerosols: Introduction**

1. Present the term “Aerosols” in the KWL.
2. Students work in teams to brainstorm what they know (K) and questions that they have (W) and share these with the class.
3. Tell students that aerosols are natural and human-made. Review the Teacher Background for more information on Aerosols. Students will review a video and try to identify the four sources and their approximate location in the movie. Play the Sources of Aerosols video with the class. (~2 min)
4. Review students findings of the sources of aerosols with the class: India (urban haze-fog), desert dust (Northern Africa), biomass burning (California, US), and ocean (salt) spray (Pacific Ocean).
5. Show the 2017 Hurricanes and Aerosols Simulation (narrated version).

Students should look for the answers to these three questions:

1. What are the three types of aerosols that this video show?
2. What are their colors?
3. Where are they concentrated?

- Sea Salt - blue
- Dust - tan (African)
- Smoke - white (North America’s Pacific Northwest)

1. Describe the video to students:

- Tracking the aerosols carried on the winds let scientists see the currents in our atmosphere. This visualization follows sea salt, dust, and smoke from July 31 to November 1, 2017, to reveal how these particles are transported across the map.
- The first thing that students may notice is how far the particles can travel. Smoke from fires in the Pacific Northwest gets caught in a weather pattern and pulled all the way across the US and over to Europe. Hurricanes form off the coast of Africa and travel across the Atlantic to make landfall in the United States. Dust from the Sahara is blown into the Gulf of Mexico. To understand the impacts of aerosols, scientists need to study the process as a global system.
1. Set the stage by explaining to the students that they will be reviewing graphs of aerosol and cloud cover percentage taken of the tropical Atlantic during 2015 and 2016.

2. Distribute Map of Research Area, identify the 29°N latitude in the tropical region of the Atlantic. Have students label the continents. Identify the different lines of longitude along the 29°N latitude on their map. Note: the map only features major meridian (0, 30°, 60°) lines so students must infer the 75°W, 45°W, 15°W, and 15° E. Students should draw these lines in using a ruler. Ask students what they already know about this region. Students may likely mention that this region is characterized by hurricanes and tropical storms, warm ocean temperatures, Northeast Trade Winds, Prevailing Westerlies, etc.

3. Distribute the Student Data Sheet (note: one sheet contains two copies). Review the Claim, Evidence, Reasoning. For more information on the use of the C-E-R Chart, see MND Lesson: Introduction: Building Claims from Evidence or the CER Youtube Video. Distribute the C-E-R Rubric and review with students.
4. Now, distribute the 2015 graphs to students. Together review the January graphs: Aerosol and Cloud Coverage. Point to the graphs’ titles, units, labels, etc. Identify the location of these graphs along the Map.

5. Together, model the process of making an observation with students by first identifying longitude band:
1.) 75°W-45°W  2.) 45°W - 15°W  3.) 15°W - 15° E
Part 4: Jigsaw Learning

1. We will use a Jigsaw Teaching Model to help students process the data in the graphs more efficiently. Initially, divide the class into five groups (January, April, July, October, December). Students will be assigned different months of 2015 to review first. Allow students to work in their team to review the graphs for their month for about 3-5 minutes.

2. Next, students will work together to create a claim that links aerosols with the formation of cloud cover percent. They will write this on the top of the Student Data Sheet. Encourage students to include variables such as month, season, or degrees longitude into their claim statements.

Possible claims could include:

- The more aerosol concentrations during the XX months, the more/less cloud cover in the XXX months. (and vice versa)
- The more concentrations of aerosols in XXX longitude, the more/less cloud cover in XXX longitude.

3. Next, further divide each group into three: 1.) 75°W - 45°W, 2.) 45°W - 15°W, and 3.) 15°W - 15° E so that students can focus their observations and then share with their larger group.

   1. Students will continue to review the graph but this time only in their latitude bands. They will make qualitative and quantitative observations and write these under the 2015 Evidence columns.

   2. Next, have students review their evidence in light of their Claim. Does this support the Claim? If so, how? If not, why not? Write these ideas briefly in the space provided. (This could be done for homework.)

   3. Students should return their team and report their findings. Repeat Steps 6-7 but for 2016 data.

Wrapping Up:

1. Students should create a larger data table showing their information in the Student Data Sheet as on a sheet of paper, butcher paper, dry erase board, or PPT/Google Slide to present to the class. This data table should summarize the Team’s works. Students share their claims and describe why the claim is valid and include the following. NOTE: Students' claims may not have been substantiated with evidence. This is ok. Students should describe as to why the Claim was insufficient.

   - the general scientific principle that supports this claim
   - background/ prior knowledge and reasoning with the class
   - scientific data that supports the claim through data taken from the graphs with specific examples referenced from different longitude bands, variable, month, and year

2. Independently, have students complete the Learn part of the KWL and share out.
Background Information

The atmosphere is a mixture of gases including nitrogen, oxygen, carbon dioxide, and other trace gases. Additionally, the atmosphere contains small, suspended liquid and particle matter called aerosols. Aerosols come from various sources, both natural and anthropogenic (man-made). Some examples are volcanic ash, dust, sand, sea salts, industrial pollutants and smoke from biomass burning.

Aerosols are important to study and monitor because they have direct and indirect effects on regional weather and global climate. Depending upon their exact nature, aerosols can affect the surface air temperature and important cloud properties. For instance, some aerosols can scatter back the sun’s radiation to space (a cooling effect at the surface). Other aerosols can absorb radiation, keeping radiation from escaping to space (a warming effect at the surface). Some other aerosols can change cloud particle sizes, invoke chemical reactions, or even suppress cloud formation (modifying cloud properties). The overall effect of aerosols on global surface temperature and clouds is still being determined and is heavily debated in the field of Earth science.

There are several NASA satellite instruments currently monitoring the Earth’s atmosphere to measure aerosols. The satellite does not directly measure the aerosol concentration, but rather the instruments measure aerosol optical depth, sometimes called aerosol optical thickness. The aerosol optical depth describes the extent that aerosols reduce the passage of sunlight through the atmosphere by scattering or absorption. The larger the optical depth, the less radiation reaches the Earth’s surface.

One of the questions that NASA scientists are trying to answer with data from the Aqua, Cloudsat, and CALIPSO satellites is what impact warm, dry, dusty air blowing out of the Sahara Desert might have on hurricane formation in the Atlantic. Does the dry air suppress hurricane formation, or does dust provide seeds for clouds, prompting storm formation? Together, the three satellites reveal humidity, aerosols (dust), temperature, and cloud structure within the layer of Saharan air, which allows scientists to map out these characteristics of the air mass in relation to where and when hurricanes form. By understanding where Saharan air is in relation to hurricanes, scientists can then observe what impact the air might have on storms.

In this lesson, you will be exploring real NASA satellite data from the Multi-angle Imaging Spectroradiometer (MISR) instrument to examine the transport of desert dust off the west coast of Africa. Desert dust warms the atmosphere regionally by absorbing radiation and suppressing storm cloud formation. For more information, visit GLORY: The Cloud Makers, NASA.

Teachers’ Notes:

The Monthly Aerosol Optical Depth data used in this lesson were collected from NASA’s MISR (Multi-angle Imaging SpectroRadiometer) instrument onboard the Terra satellite. Students will notice that these line graphs may not be complete, meaning that there are gaps in the data. The missing data could be due to a variety of reasons such as problems with the sensor’s performance, communications, or reception, for example.

These gaps provide a teachable moment to address a tenant of the Nature of Science: Science
demands evidence. Scientific knowledge is derived from data and evidence gathered by observation or experimentation. Scientists prefer to control the conditions to obtain their data, however, this is not always practical (like studying the Earth from a satellite). In these cases, observations must be made over a large period of time so that scientists can collect a wide base of evidence. This reliance on evidence makes the development of better technologies and observation techniques very important.

**Why Does NASA Study This Phenomenon?**

In this lesson, students will view a simulation of satellite data to observe aerosols moving across the Earth’s atmosphere where they will examine the transport of desert dust off the west coast of Africa. Desert dust warms the atmosphere regionally by absorbing radiation and suppressing storm cloud formation.