Observing Visibility and Sky Color

Purpose

To observe, document, and classify changes in visibility and sky color over time and to understand the relationship between sky color, visibility, and aerosols in the atmosphere

Student Outcomes

Students become aware of the changes in visibility and sky color due to particles suspended in the air.

Overview

Science Concepts

Earth and Space Science

- The atmosphere is composed of different gases and aerosols.

Geography

- Human activities can modify the physical environment, specifically air quality and the composition of the atmosphere.

Atmosphere Enrichment

- Aerosols decrease the amount of solar energy reaching Earth's surface.
- Aerosols in the atmosphere increase haze, decrease visibility, and affect air quality.

Scientific Inquiry Abilities

- Identify answerable questions.
- Observe and describe sky conditions.
- Develop descriptions and explanations using evidence.
- Recognize and analyze alternative explanations.
- Communicate procedures and explanations.

Time

Initial observations: 20 minutes

Continued observations: 10 minutes

Level

All

Frequency

Initial observations: for five to ten days, days with limited cloud covered preferred

Continued observations: throughout the year, days with limited cloud covered preferred

Materials and Tools

- Colored pencils or water-colored paint and brushes
- White paper
- Optional: camera or paint sample cards (from a local paint store)
- *Visibility and Sky Color Data Sheet*
- *Visibility and Sky Color Summary Chart*
- Scissors and tape

Preparation

None

Prerequisites

Cloud Cover Protocol

Background

Why is a clear sky blue? The atmosphere consists primarily of molecules of oxygen and nitrogen. Sunlight bounces off these molecules, a process called scattering. Light with shorter wavelengths, at the blue end of the visible light spectrum, is scattered more efficiently than longer wavelengths. To an observer on the ground, this scattered light fills the entire sky and a clear sky appears blue.

However, there are also liquid and solid particles called aerosols suspended in the atmosphere. When there are relatively few aerosols, the sky appears clear. For example, a distant building or mountain peak appears clearly defined, with colors similar to what you would see if you were much closer to that distant object. On a very clear day, you would report the sky color as blue or deep blue and the sky condition as clear or unusually clear. Aerosols come from natural sources such as condensation and freezing water vapor, volcanoes, dust storms, and salt crystals evaporated from sea spray. They also come from human activities such as burning fossil fuels and biomass (e.g., wood, dung, dried leaves) and plowing or digging up soil. Aerosols are much bigger than gas molecules (they range in size from about 10^{-6} m (1 micron) to 10^{-7} m) and they scatter light from all visible wavelengths. Individual aerosols are too small to be visible to the human eye, but their presence affects the sky's appearance. As the aerosol concentration, and therefore scattering of sunlight, increases, the sky appears less blue. Haze is the visible effect of aerosols on the atmosphere; it is a qualitative condition you can observe. When aerosol concentrations are high, we say that the sky looks hazy. Aerosol concentrations can also be measured quantitatively.

Hazy skies appear pale blue or almost white. Depending on the type of aerosols present in the atmosphere, the sky may also appear brownish or yellowish. Scattering of visible light through a hazy sky affects horizontal visibility, so distant objects appear less distinct, with washed-out or distorted colors. Distant objects that are visible on a clear day may actually disappear on a hazy day.

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Aerosols, probably produced by urban smog, cause the haze evident in this picture of the Empire State Building in New York City. Over the past few decades, horizontal visibility has declined around the globe, on average, due to increasing aerosol concentrations. As a result, scenic vistas throughout the world have been obscured.

Teacher Preparation

In this activity, your students will carefully observe the atmosphere over a period of days and record their observations. Through these direct observations they will develop an understanding that visibility and sky color are related and that both are due to the relative presence or absence of aerosols.

The students will classify the sky color using standard categories and will represent the sky color using paints or colored pencils. They also will record the visibility based on observation of a distant object such as a mountain or a building. It is not important that they observe every day, but they should try to sample a wide range of the visibility and sky conditions that occur at your location. They should try to observe on some very clear days, on some hazy days, and on some intermediate days. After they have observed and recorded examples of very clear days, very hazy days, and various conditions in between, the class will record their observations in a summary table and see whether or not a pattern emerges that relates visibility to sky color.

Visibility

By "visibility" we mean the clarity with which objects can be viewed through the intervening atmosphere. In order to judge visibility or the clarity of the atmosphere, students need to be able to look out at 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. Only practice, lots of different examples, and discussion will make these categories clear. (No pun intended!)

Sky Color

Students are also asked to observe, classify, and represent the sky color. They will classify the sky color using the categories listed at the bottom of the data sheet. They represent the sky color in a drawing using paints or colored pencils. They could also try using photographs or color paint chips. As they make more observations, the students will become more confident of their classifications and more skillful in drawing the sky color.

Students may notice that the sky is often a different color in different parts of the sky. Near the horizon it is typically lighter due to the presence of aerosols. The darkest part of sky can often be seen about half way between the horizon and directly overhead, in the "anti-sun" direction – that is, when you look at the sky with your shadow in front of you. Students should try to locate the darkest (bluest) color of the sky and record it.

Correlation Between Visibility and Sky Color

One of the purposes of this activity is for students to realize that on the clearest days with the highest visibility the sky is a deep blue color, while on hazy days it appears milky. Changes in visibility and sky color are both due to changes in aerosol concentrations in the atmosphere. Because aerosols scatter sunlight, high aerosol concentrations make it harder to see distant objects and make the sky appear lighter. On clear days when aerosols are low, visibility is high and the sky is deep blue. But do not TELL students this; let them discover it by pooling the class observations in the *Visibility and Sky Color Summary Chart*. It *should* be the case that most of their observations will tend to fall along the main diagonal from upper left to lower right.

What To Do and How To Do It

1. Lead students through a discussion of aerosols, visibility, and sky color. Begin by asking them what they recall about times when the sky was very hazy. How was the visibility? How did they recognize that visibility was low? What color was the sky? When did this occur? What do they think caused it?
2. Continue by asking them to recall a time when the sky was very clear. What did it look like? What color? How was the visibility through the atmosphere? When did this very clear event occur? What was the weather like at that time? What do they think caused the air to be so clear at that

time?

3. If it has not already come up in discussion, discuss the role of aerosols in the creation of haze. Discuss local and regional sources of aerosols. Discuss, also, how aerosols such as dust can be transported from long distances and affect local conditions.
4. Explain that they will undertake an investigation of sky color and visibility. Introduce the *Visibility and Sky Color Data Sheet* and discuss how to use it. Take observations for as many days as necessary to obtain a full range of sky conditions in the data.
5. After the class has made a large number of observations, covering the entire range of sky conditions that occur in your area, bring the class together for a group discussion of the data. Engage the students in a discussion of the conditions that existed when they observed the clearest and their haziest skies. What was the weather like? What do they think accounted for the clearest and the haziest skies? When they had hazy skies, was the haze created by local, regional, or long-distance factors?
6. On the blackboard or on chart paper, create a chart similar to the *Visibility and Sky Color Summary Chart* shown. Invite students to contribute their data to the chart by placing a mark in the appropriate cross-classification cell to represent each of their observations.
7. When the chart has been populated with all of the student observations you should observe a diagonal trend in the data, from upper left to lower right. Ask students to explain why this trend exists. What is the common element that causes both low visibility and milky skies?
8. (Optional) Have each student or team create a "key" to help them make future observations. Select one sky color example for each level of visibility/sky color from "unusually clear" to "extremely hazy." Use these keys to standardize your observations of haze conditions. Students can continue to take observations throughout the year and note relationships to season, storms, time of day, temperature, wind direction and other conditions. Depending on students' ages, these color keys can be sky paintings, photographs, or paint color chips that can be obtained from stores that sell interior paint.

Student Preparation for Observing Visibility and Sky Color

Make these observations only on days when you can see the sky. Do not attempt to observe visibility and sky color on days that are overcast. For each day that you make an observation, record the date, the local time, your estimate of the visibility and your estimate of the sky color.

Both visibility and sky color are subjective classifications. That means you should expect some variation among observers and changes in your own classifications as you gain experience. As you gain experience in observing the atmosphere and the sky you may change your mind about some of your initial classifications. You may decide that what you originally classified as a deep blue sky you now consider to be merely "blue." Or, you may decide that what you thought was "somewhat hazy" was really "very hazy." Do not worry about this and do not go back and change your original observations. You can expect your skill in classifying to evolve and change. Gradually, you should gain confidence in your ability to classify consistently.

1. Estimate the visibility.

Select some distant object – a mountain range, a building, or other object several kilometers away. Use this object as your "reference object" to judge visibility every day you make an observation. Take note of how distinctly you can see it and select one of the visibility categories below and record it on the *Visibility and Sky Color Data Sheet*.

Unusually clear
Clear
Somewhat hazy
Very hazy
Extremely hazy

2. Observe the sky color.
   Now look at the sky and find the part of it that is the darkest color. When you do this activity, be sure not to look directly at the sun even if it is partially obscured by clouds. Select a category for the sky color from the list below and record it on the *Visibility and Sky Color Data Sheet*.

   Deep blue
   Blue
   Light blue
   Pale blue
   Milky

3. Paint or draw with colored pencils your best representation of the sky color in the "picture" box. You can also use paint color chips or photographs to represent sky color.

Questions for Understanding

1. When you see blue skies, what other weather conditions are likely to exist? What else would you observe on very clear days?
2. Are you aware of any daily patterns in sky color and visibility in your location? Is it usually hazier at certain times of day? What causes this?
3. How are sky color and haze related to weather?
4. Are sky color and haze at your location related to the amount of wind and the wind direction? If so, why?
5. Are sky color and haze at your location related to the time of the year? That is, are there seasonal patterns in your data?

Visibility and Sky Color Data Sheet

Observer(s): _____

_____

Date	Local Time	Visibility (use categories below)	Sky Color		Comments: weather conditions, wind direction, etc.
			Category (see below)	Draw the Color *	

*Alternatively, you can give the name of a paint color, or you can refer to a photograph you have taken previously.

Visibility Categories	Sky Color Categories
Unusually clear	Deep blue
Clear	Blue
Somewhat hazy	Light blue
Very hazy	Pale blue
Extremely hazy	Milky

Visibility and Sky Color Summary Chart

Make a mark or an “x” in the cell of the chart where each observation falls.

Visibility/Sky Color	Deep blue	Blue	Light blue	Pale blue	Milky
Unusually clear					
Clear					
Somewhat hazy					
Very hazy					
Extremely hazy					

What do you notice about the pattern of observations?

How can you explain this pattern?