Lesson One
Start with: The Atmosphere

Content Summary

In this first "Climate and Weather" lesson, students are introduced to the atmosphere and study the unique characteristics and properties of each layer. They also explore ways in which the atmosphere protects us, and ways in which we can protect the atmosphere.

Lesson Materials

- *Fresh Science* Climate and Weather DVD
- Lesson 1 ACTIViewer™ recording sheets (Pages 25 and 26); one copy per student
- "Start with: The Atmosphere" Reading, Writing and Thinking Activities (Pages 17-21); one copy each per student
- "Mapping Ozone in the Stratosphere" Hands-on Activity (Pages 22-24); one copy per student
- 11 x 14 grid paper; one sheet per student

Key Concepts

The following concepts are featured in **bold** in this lesson and appear in the DVD's Illustrated Glossary.

air
anemometer
atmosphere
atom
barometer
climate
exosphere
mesosphere
meteorologist
mixture
molecule
oxygen
ozone
precipitation
radiation
stratosphere
thermometer
thermosphere
troposphere
ultraviolet (light)
water vapor
weather

Pacing

This video lesson should take about 30 minutes to complete, depending upon the degree of student interactivity. Additional time is required for students to complete the Reading, Writing and Thinking Activities; the Video Quiz; and the Hands-on Activity.

Student Objectives

- **Comparing and contrasting weather and climate**
- **Analyzing the structure and composition of the atmosphere**

Appetizer

"START WITH: THE ATMOSPHERE" (T)

Ask student volunteers to describe the most amazing weather day they can ever recall. Encourage students to use both qualitative and quantitative descriptors. Write their key words or phrases on the chalkboard.

Continue the discussion by asking some or all of the following questions.

- What impact did this amazing weather day have on your life?
- How did that weather make you feel?
- Were you inconvenienced? Was anyone else?
- Did you know this amazing weather day was coming?
- If so, did you make plans because you knew it was coming?
- If not, would you have changed your plans had you known?
- Did you or other family members spend money as a result of the weather circumstance?
- Who might have made money as a result of it?
- Does a particular sound, song, color or smell make you recall that weather day?

Move to a more global discussion on weather by asking the following questions.

- What types of jobs are directly affected by weather?
- What types of jobs depend upon certain weather conditions?
- What type of weather most impacts your day-to-day activities?
- Is it important for you to know about potential weather conditions? Why or why not? PLAY ▶

MIAMI, MAY 12, 1997 (NVB); FIRST FRAME OF NARRATED VIDEO BITE

Tell students that even with all the modern tools available to us, including satellite images from space, the weather still can catch us by surprise at times. On Monday, May 12, 1997, some Florida residents witnessed a surprise weather event that was captured on tape by a rooftop video camera as well as by many amateur videographers. Here's what they saw. PLAY ▶ *[55 seconds duration]*

MIAMI, MAY 12, 1997 (NVB) • NARRATED VIDEO BITE

> *"If you think tornadoes don't touch down in large metropolitan cities, think again. Now residents in Miami, Florida, had never seen such a sight as this—sure they have their share of severe thunderstorms, occasional waterspouts and short-lived funnel clouds that last just a minute or so. But to see a tornado cruising by Miami's high-rise apartments*

in the middle of a Monday afternoon in May was, well, it was amazing, actually. Sure, it was dangerous—the 100 mile-per-hour winds were enough to uproot trees, shatter glass windows and throw lots of debris into the air. And people ran for cover—well, those who didn't have video cameras in their hands did, anyway. As a result, nobody was seriously hurt. But this tornado—that was on the ground almost 15 minutes, causing almost a half million dollars worth of property damage—will always be remembered by the striking images made as it toured downtown Miami, in no particular hurry."

MIAMI, MAY 12, 1997 (NVB); LAST FRAME OF NARRATED VIDEO BITE

Explain to students that probably the most interesting thing about the Miami tornado is that as rare as this weather event was, it was forecast almost 24 hours earlier by the National Weather Service Forecast Office in Miami. Actually, strong upper-level air disturbances and hot, humid air—the conditions that were favorable for producing supercell thunderstorms—storms that spawn tornadoes—were well forecast. So when this tornado materialized, the people most surprised by it were those who had not heard a recent weather report.

But in the absence of a weather report, you can look around you to get a sense of where the weather is headed. And the more you know about why weather exists, the better you'll be at spotting clues to the weather that's on the way.

Tell students that in this and the next four lessons, they will be introduced to the causes of weather while experiencing some of the most amazing, and scary, weather conditions offered on this planet. Then, distribute a copy of the "Start with: The Atmosphere" ACTIViewer™ recording sheets (Pages 25-26) to each student.

Let the following narrative help steer your discussion with students. Those of you who are unfamiliar with or uncomfortable with the subject matter might want to stick fairly closely to the prepared script—paraphrasing it and customizing it to fit your particular teaching style. The visuals on the DVD are ordered based on the lesson plan, so all you need to do is watch for video and print cues telling you when to advance the DVD.

Those of you who are well versed in the subject of climate and weather can use these visuals to support your own lessons. If you prefer to use the visuals only, though, you might want to visit the Visuals a la Carte section of the DVD to help you navigate more easily through the images.

Regardless of how you choose to use the materials we've provided, remember that above all, *you* are guiding this lesson, it is not guiding you. Move through it at a pace that's comfortable for you and your students. Encourage questions and interactivity. If you're unsure of answers, have students further research their questions on the Internet. Or e-mail the question to us at **Questions@FreshScience.com**. We're eager to help you succeed. PLAY ▶

Main Course

WHAT IS WEATHER? (T)

How would you describe weather? Well, for starters, **weather** *(IG L1)* is defined as the "state of the atmosphere at a given time and place with regard to temperature, air pressure, wind, humidity, cloudiness and precipitation." PLAY ▶

VARIOUS WEATHER SCENES (VB); FIRST FRAME OF VIDEO BITE

Weather is something we observe. Weather has qualities we measure, such as temperature, wind direction, wind speed, and form and amount of **precipitation** *(IG L1)*. We look at the sky to describe the weather — it's raining, it's cloudy, it's sunny. PLAY ▶ *[18 seconds duration]*

VARIOUS WEATHER SCENES (VB); LAST FRAME OF VIDEO BITE

We use various tools to measure and collect daily weather data... PLAY ▶

THERMOMETER (P)

...a **thermometer** *(IG L1)*... *[press* PLAY ▶ *to zoom in on the thermometer]* PLAY ▶

BAROMETER (P)

…a **barometer** *(IG L1)*… *[press* PLAY ▶ *to zoom in on the barometer]* PLAY ▶

ANEMOMETER (P)

…an **anemometer** *(IG L1)*… *[press* PLAY ▶ *to see the anemometer in action]* PLAY ▶

RAIN GAUGE; START OF ZOOM (P)

…a rain gauge *[press* PLAY ▶ *to zoom in on the rain gauge]*.

RAIN GAUGE; END OF ZOOM (P)

The scale on this rain gauge shows inches at left and millimeters at right. According to the water level in the gauge, how much rain has fallen? *[One inch plus two-tenths of an inch; 30 millimeters]*

Nevertheless, even with all those tools available, Harold Gibson, a Chief Meteorologist at the New York City Weather Bureau, once said, "The best weather instrument yet devised… PLAY ▶

HUMAN EYES (P)

…is a pair of human eyes." *[press* PLAY ▶ *to see the human eyes in action]*

The weather you experience today probably won't be the same weather you experience in two months, or maybe even in two days. But the climate may be the same. So what's the difference between weather and climate? PLAY ▶

WHAT IS CLIMATE? (T)

Someone once said, "Climate is what you expect, weather is what you get." PLAY ▶

VARIOUS SCENES OF REGIONS HAVING DIFFERENT CLIMATES (VB); FIRST FRAME OF VIDEO BITE

Climate *(IG L1)* is the long-term average of a region's weather. In other words, it is the typical weather that prevails from season to season and year to year. So, when an area is described as having a warm, wet climate, that means that the weather there is predictably warm and wet many days of the year, year after year. These next images show various climate regions on Earth. Based on what you see, can you guess where they might be? PLAY ▶ *[6 seconds duration]*

VARIOUS SCENES OF REGIONS HAVING DIFFERENT CLIMATES (VB); LAST FRAME OF VIDEO BITE

Well, we saw a lush, tropical rain forest near the equator in Brazil, a desert in Arizona and a frozen landscape in northern Canada. All of these areas have climates that are dramatically different from one another.

Climate depends on many factors. PLAY ▶

METEOROLOGISTS AT WORK (VB); FIRST FRAME OF VIDEO BITE

A **meteorologist** *(IG L1)*, a scientist who studies climate and weather, considers such factors as the movement of air, its temperature and pressure. He or she observes clouds and monitors rain and snowfall. A meteorologist also studies weather trends over time. Then, using these data, he or she tries to accurately predict what the weather will be like over the next several days. PLAY ▶ *[29 seconds duration]*

METEOROLOGISTS AT WORK (VB); LAST FRAME OF VIDEO BITE

The American Meteorological Society defines a meteorologist as a person with specialized education "who uses scientific principles to explain, understand, observe, or forecast Earth's atmospheric phenomena and/or how the atmosphere affects Earth and life on the planet." Many meteorologists have degrees in physics, chemistry or mathematics. They're smart people! Still, forecasting the weather, one of the main focuses of many meteorologists, isn't an easy job for them. PLAY ▶

ARNOT SHEPPARD QUOTE (I/D)

A fellow by the name of Arnot Sheppard offers us this quote on meteorologists, "There is little chance that meteorologists can solve the mysteries of weather until they gain an understanding of the mutual attraction of rain and weekends." Even though his statement is tongue-in-cheek and there's no scientific evidence to support it, there does seem to be a little truth to it, don't you think? How many times has this happened to you: the weather is beautiful all week long while you're in school, and then along comes the weekend, and with it, bad weather? Meteorologists may not know *everything* about the weather, but they know one thing for sure—it occurs in the air above us. And so, knowledge about the structure and composition of that air is key to understanding the weather. PLAY ▶

EARTH SPINNING IN SPACE; ATMOSPHERE VISIBLE (A)

Earth is made mostly of rock; a relatively thin layer of water covers three-fourths of its surface, and the entire planet is surrounded by a thin blanket of **air** *(IG L1)* called the **atmosphere** *(IG L1)*. PLAY ▶ *[This animation is 13 seconds in duration. When the video stops, press* PLAY ▶ *to move to the next image, which begins on a blue background.]*

PIE CHART SHOWING COMPOSITION OF EARTH'S ATMOSPHERE (A); FIRST FRAME OF ANIMATION

At least until about 88 kilometers above our heads, the atmosphere is a constant **mixture** *(IG L1)* of nitrogen and **oxygen** *(IG L1)* gases… PLAY ▶ *[8 seconds duration]*

PIE CHART SHOWING COMPOSITION OF EARTH'S ATMOSPHERE (A); LAST FRAME OF ANIMATION

…78 percent nitrogen and 21 percent oxygen, with small amounts of **water vapor** *(IG L1)*, carbon dioxide and other trace gases making up the remaining one percent. PLAY ▶

PARTICLES IN EARTH'S ATMOSPHERE (A); FIRST FRAME OF ANIMATION

The atmosphere carries lots of dust that comes from the surface and from meteors. And it also contains microorganisms, salt and pollen. PLAY ▶ *[16 seconds duration]*

PARTICLES IN EARTH'S ATMOSPHERE (A); LAST FRAME OF ANIMATION

And to all that, we add our share of pollutants. PLAY ▶

CROSS-SECTION OF M&M'S CANDIES (P)

The atmosphere has distinct layers. Think of a layer like a shell enveloping our planet—kind of the way that a candy-coated shell envelops an M&M. Unfortunately, our atmosphere isn't tasty like an M&M candy, but that's a discussion for another day... PLAY ▶

LAYERS OF EARTH'S ATMOSPHERE (I/D)

In the case of Earth's atmosphere, there isn't just one layer—there are five basic layers or shells based on air temperature. PLAY ▶

TROPOSPHERE (I/D)

The lowest level, that layer in which we lead our day-to-day lives, is called the **troposphere** *(IG L1)*. It extends an average of 10 kilometers above the surface. *[Actually, the troposphere is thickest at the equator (14 kilometers), and thinnest at the poles (8 kilometers)]*. Most weather events occur in the troposphere, so that's the layer of the atmosphere that will be closely studied later in this lesson. PLAY ▶

TROPOSPHERE TEMPERATURES (A); FIRST FRAME OF ANIMATION

Watch how the temperature, shown in red, decreases sharply with altitude. PLAY ▶ *[5 seconds duration]*

TROPOSPHERE TEMPERATURES (A); LAST FRAME OF ANIMATION

That's because the air in the troposphere is heated more by Earth's surface than by the sun. The sun's energy is absorbed by the earth, which in turn warms up the atmosphere most closely surrounding it.

And about where the temperature in the troposphere reaches its lowest point, a frigid –58° C, the second layer of the atmosphere—the stratosphere—begins. PLAY ▶

STRATOSPHERE (I/D)

The **stratosphere** *(IG L1)* extends from about 10 kilometers to about 48 kilometers overhead. Temperatures hold steady in the lower stratosphere, and then gradually increase with altitude. Few clouds can be found in the stratosphere—it's very dry. And it has a steady, horizontal wind—none of the vertical winds we have in the troposphere. But more on that later. PLAY ▶

STRATOSPHERE TEMPERATURES (I/D)

Just where temperatures level off in the stratosphere, returning to a balmy –2° C or so, a new layer begins… PLAY ▶

MESOSPHERE (I/D)

…the mesosphere. We'll get to the mesosphere in a moment. First, it's stratosphere appreciation time. PLAY ▶

SUN (P)

Light from the sun, while making life on Earth possible, can also have harmful effects. PLAY ▶

MELANOMA (P)

Specifically, **ultraviolet** (also known as UV) *(IG L1)* **radiation** *(IG L1)* from the sun can damage your skin, causing all types of skin cancer and premature aging. PLAY ▶

WRINKLED, TANNED SKIN (P)

Want to avoid getting freckles and wrinkles like these when you're older? PLAY ▶

SUNSCREEN; SPF 25 (P)

Then be sure to cover your exposed skin with sunscreen that has a high Sun Protection Factor, or SPF, when you plan to spend time in the sun. PLAY ▶

UV RAYS ABSORBED BY OZONE LAYER IN STRATOSPHERE (A); FIRST FRAME OF ANIMATION

The good news is that the atmosphere blocks much of the ultraviolet radiation from reaching Earth's surface. Present mainly in the upper stratosphere, and concentrated at an altitude of about 25 kilometers, is a type of oxygen **molecule** *(IG L1) [made up of three oxygen* **atoms** (IG L1)*]* called **ozone** *(IG L1)*. Actually, about 85 percent of the total ozone in the atmosphere is found in the stratosphere. The other 15 percent of atmospheric ozone is down in the troposphere causing all sorts of problems. Ozone at our level is considered an air pollutant. It is a main ingredient of urban smog.

But strangely enough, ozone in the stratosphere is actually a good thing. Ozone absorbs much of the UV radiation coming in from space. As the ozone molecules soak up the UV rays, solar energy is converted to kinetic energy, resulting in heating of the stratosphere. The more ozone, the more the temperature increases. PLAY ▶ *[10 seconds duration]*

UV RAYS ABSORBED BY OZONE LAYER IN STRATOSPHERE (A); LAST FRAME OF ANIMATION

And so, let's hear it for the stratosphere! With its abundance of ozone, the stratosphere plays a critical role in protecting life on Earth from harmful radiation. PLAY ▶

CHLOROFLUOROCARBONS (A); FIRST FRAME OF ANIMATION

[NOTE: First frame is black.] But guess what? Down in the troposphere, our neck of the woods, we've been doing our share to mess up the stratosphere. In about 1935, certain gases called chlorofluorocarbons (CFCs) were invented. PLAY ▶ *[12 seconds duration]*

CHLOROFLUOROCARBONS (A); LAST FRAME OF ANIMATION

Some CFCs were coolants for refrigeration units… PLAY ▶

AEROSOL SPRAY CAN (A); FIRST FRAME OF ANIMATION

…and some CFCs were propellants packed with paint, insecticide or hairspray in pressurized canisters, or spray cans. PLAY ▶ *[3 seconds duration]*

AEROSOL SPRAY CAN (A); LAST FRAME OF ANIMATION

Some CFCs were solvents, good for dissolving grease or cleaning electronic components and certain metals. PLAY ▶

CFC MOLECULES BREAKING INTO CHLORINE ATOMS (A); FIRST FRAME OF ANIMATION

Today, many of those CFC molecules—there's one depicted down in the lower left corner of this artist's drawing—are present in the troposphere. When they float up into the stratosphere, they react with the strong UV radiation there and break apart into chlorine atoms and other fragments. The chlorine atoms alter the ozone molecules—we can see two here, each made up of three atoms of oxygen, shown in green—by breaking them apart into oxygen molecules. Watch. PLAY ▶ *[28 seconds duration]*

CFC MOLECULES BREAKING INTO CHLORINE ATOMS (A); LAST FRAME OF ANIMATION

Did you see what happened? The chlorine atom, shown in pink, broke apart from the CFC molecule, bumped into an ozone molecule and picked up one of its oxygen atoms, leaving behind an oxygen molecule. Then, the chlorine and oxygen molecule (chlorine monoxide) split up when another oxygen atom came along. That left the chlorine atom free to go break up another ozone molecule. Indeed, one chlorine atom can break apart more than 100,000 ozone molecules. And that's a problem. The beneficial ozone is destroyed. Thus, the stratosphere's ability to block the ultraviolet radiation is diminished. PLAY ▶

TOMS DATA SHOWING OZONE LEVELS IN THE ATMOSPHERE (A); FIRST FRAME OF ANIMATION

CFC gases are partially responsible for what are called holes, but which actually are reductions, in the ozone layer of the stratosphere. This video is an animation of real images showing ozone levels in the atmosphere. The images were acquired by the Total Ozone Mapping Spectrometer, or TOMS, aboard the Nimbus-7 satellite. The TOMS makes 35 measurements every 8 seconds. In this false-color image, higher than normal levels of ozone are shaded red and yellow. Normal or average levels of ozone are shaded greenish-yellow. Light blue is slightly below normal ozone levels. Dark blue is well below normal. Purple is extremely low. PLAY ▶ *[15 seconds duration]*

TOMS DATA SHOWING OZONE LEVELS IN THE ATMOSPHERE (A); LAST FRAME OF ANIMATION

Over what areas was the largest concentration of ozone? *[Just north of Antarctica]* Did you see any "holes" in the ozone layer? *[Most of the atmosphere above Antarctica has reduced ozone levels (dark blue areas). The atmosphere above the center of the continent seems to be hardest hit.]* The most noticeable losses of ozone typically occur over the poles. That's because ozone depletion accelerates in extremely cold weather.

Today CFC production in the United States has been banned. *[You might have students research the Montreal Protocol in which signatory nations committed themselves to a reduction in the use of CFCs and other ozone-depleting substances.]*

Even though we have reduced or eliminated the use of many CFCs, it may be 40 years before ozone levels in the stratosphere return to normal. PLAY ▶

TROPOSPHERE AND STRATOSPHERE LABELED (I/D)

Ninety-nine percent of all the air in the atmosphere is within the troposphere and the stratosphere. And where there's air, there's weather. But since we're talking about the layers of the atmosphere, we'd better at least mention its three top layers. PLAY ▶

ATMOSPHERE; "MIDDLE LAYER" LABELED (I/D)

Earlier, you learned that the middle layer of the five atmospheric layers is called the **mesosphere** *(IG L1)*. *Meso-* means "middle." PLAY ▶

ATMOSPHERE; MESOSPHERE LABELED (I/D)

As altitude increases in the mesosphere, the temperature decreases. At the lowest point in the mesosphere, about 50 kilometers above Earth's surface, the temperature is near –2° C. At about 83 kilometers above the surface, the highest point in the mesosphere, the temperature has plunged to –90° C. Now that's cold! PLAY ▶

LEONIDS METEOR STORM (NVB); FIRST FRAME OF NARRATED VIDEO BITE

If you've ever looked up at the night sky and seen a "falling star"—which actually is a meteor burning up from friction as it falls toward Earth—it most likely was in the mesosphere.

But perhaps you've never seen a meteor. Viewing conditions have to be just right—the sky has to be dark and cloudless. A fellow from Japan named Osamu Okamura, a member of the Nippon Meteor Society, often wondered what it would be like to observe meteors from a high altitude—above the haze and clouds and away from light pollution. And so, on November 17, 1999, a date when the annual Leonids meteor storm was to take place, Osamu boarded a night flight from Kobe, Japan, to London, England, via Kuala Lumpur, Malaysia. *[You might have a student volunteer point out these cities on a globe or world map.]* He didn't travel empty-handed. Osamu brought two video cameras that he attached to his seat and aimed out the window. For a total of 10 hours, Osamu captured hundreds of meteors on videotape as the aircraft cruised at an altitude of 11,000 meters (36,000 feet). Here's just a short clip of what Osamu saw that night, along with an excerpt from a letter he wrote, describing his experience. **PLAY ▶** *[35 seconds duration]*

LEONIDS METEOR STORM (NVB) • NARRATED VIDEO BITE

> *"The course of the flight cut through the skies of many countries between Malaysia and the UK, almost exclusively above land. Occasionally, I could see the lightning above the ground under my sight. Although the weather was bad and the airplane was frequently shaken, almost no vibration was noticeable in the video because the cameras were tightly fixed to the seat shelves. The scene of the meteor shower was spectacular, but respecting the other passengers' sleep, it was a shame that I couldn't make a noise of joyful excitement. The only persons in our airplane who witnessed this great sight were the crew and I."*

LEONIDS METEOR STORM (NVB); LAST FRAME OF NARRATED VIDEO BITE

The mesosphere never looked so good, did it? **PLAY ▶**

ATMOSPHERE; THERMOSPHERE LABELED (I/D)

Next up, the **thermosphere** *(IG L1)*. This layer, known as the upper atmosphere, is so named because of its extreme temperature variations. *Thermo-* means "heat." And here's why the thermosphere lives up to its name. At its base, its temperature is about –90° C. But at its rather poorly defined upper limit, some 600 kilometers above Earth, the temperature of the thermosphere has climbed to nearly 1700° C. **PLAY ▶**

SHUTTLE ASTRONAUTS DURING AN EVA (VB); FIRST FRAME OF VIDEO BITE

The Space Shuttle orbits Earth in the lower thermosphere. Whenever you see an astronaut out for a space walk, think about the job his or her spacesuit is doing. **PLAY ▶** *[32 seconds duration]*

SHUTTLE ASTRONAUTS DURING AN EVA (VB); LAST FRAME OF VIDEO BITE

It's actually a portable atmosphere, providing oxygen and protecting the astronaut from extreme temperatures, among other things. **PLAY ▶**

ATMOSPHERE; GAS LAYERS (I/D)

Earlier in the lesson, you learned that the atmosphere, at least until around 88 kilometers over our heads, is about 21 percent oxygen and 78 percent nitrogen. In the thermosphere, this mixture dramatically changes.

[Note: That's because the sun's energy is so strong, it breaks apart atoms and molecules of oxygen and nitrogen and other gases in the air, leaving behind what are called ions and free-floating electrons. An ion is an atom with extra or missing electrons, making it electrically charged.]

Instead of a mixture of gases, the chemicals are layered. From 88 kilometers up to about 220 kilometers, the atmosphere is primarily nitrogen. Above that, to about 1100 kilometers, there's a band where atoms of oxygen dominate. Helium rules next, up to an altitude of about 3500 kilometers, and finally, a band of hydrogen can be found. PLAY ▶

RADIO SIGNALS BOUNCING OFF IONOSPHERE (I/D)

Another notable feature of the thermosphere is that radio signals can be "bounced" off it, allowing radio communication over long distances. This region of the atmosphere is also known as the ionosphere. PLAY ▶

PARTICLES LEAVING SUN AND CAUSING AURORA (A); FIRST FRAME OF ANIMATION

[NOTE: First frame is black.] And one last thing—in the ionosphere are regions known as the auroral zones. Have you ever looked toward the North Pole at night and seen the "northern lights"? These beautiful waves of light, called aurora, are caused by particles coming from space and striking the gases in the ionosphere.

This is an artist's interpretation of what it might look like when material from the sun *[called "coronal mass ejection"]* leaves the sun and travels toward Earth. There, it strikes Earth's atmosphere and causes auroras at the poles. PLAY ▶ *[38 seconds duration]*

PARTICLES LEAVING SUN AND CAUSING AURORA (A); LAST FRAME OF ANIMATION

Do you see the aurora at both the northern and southern poles? Remember, this is an artist's rendering. PLAY ▶

AURORA BOREALIS (VB); FIRST FRAME OF VIDEO BITE

And here's the real thing—a video of the Aurora Borealis observed during the 1986 winter in Fairbanks, Alaska, and made by members of the University of Alaska at Anchorage. They use a uniquely sensitive video camera that allow them to capture the subtle colors and movements of the aurora. How sensative is the camera? Imagine this: typical film cameras use film with a sensitivity of ASA 25 to 1000. The higher the number, the less light is needed to make an image. The ultralow-light-level camera used to video this aurora has an equivalent sensitivity of ASA 2,000,000! Watch. PLAY ▶ *[22 seconds duration]*

AURORA BOREALIS (VB); LAST FRAME OF VIDEO BITE

Each gas glows with a different color, depending in part on where it is in the atmosphere. PLAY ▶

AURORA COLORS (A); FIRST FRAME OF ANIMATION

For example, nitrogen below 100 kilometers glows crimson. An oxygen atom between 100 and 200 kilometers above the surface will glow green when struck by a particle. Nitrogen at that altitude will glow blue. Watch. PLAY ▶ *[7 seconds duration]*

AURORA COLORS (A); LAST FRAME OF ANIMATION

The green glow associated with oxygen is the brightest and most common auroral color.

As you've seen, there's a lot happening in the thermosphere, but once you leave it, things quiet down considerably. PLAY ▶

ATMOSPHERE; EXOSPHERE LABELED (I/D)

The **exosphere** *(IG L1)* is the outermost layer of Earth's atmosphere; it eventually trails off into the vacuum of outer space. PLAY ▶

EXOSPHERE (I/D)

There isn't much to the atmosphere out this far. Mainly hydrogen and helium atoms float about, and they are few and far between. How far between? Get this: the average distance molecules travel *without hitting other molecules* in the exosphere is about 6300 kilometers! That's nearly equal to the radius of Earth.

Out in the exosphere, we're about as far away from our weather as one can be in the atmosphere. So, since this unit is about weather, we need to return to the troposphere, where you'll find the ingredients for any type of weather you want. Only trouble is, we're out of time for today. In our next science lesson, we'll add the sun and water to the atmosphere and see what results.

Dessert

You've got decisions to make!

Option 1. Hands-on Activity (25 minutes)

Have students complete the "Mapping Ozone in the Stratosphere" Hands-on Activity (Page 22-24). Students develop a graph that shows ozone levels in the stratosphere over a 14-year period. Then, they answer questions based on the information in the graph.

Option 2. Reading, Writing and Thinking Activities (25 minutes)

Have students complete the "Start with: The Atmosphere" Reading Activity (Pages 17-19). The reading passage summarizes the information presented in the video lesson. Then, students can either complete a writing exercise (Page 20) or prepare a written response to one of the higher-order thinking questions (Page 21).

Option 3. Video Quiz (10 minutes)

Have students take the video quiz. It is intended to check students' mastery of concepts. The questions are designed so that you can present them in either of two ways.

Standard Mode { Show the question. Show students four possible answers. Have students choose the best answer and write it down. Show the correct answer.

Challenge Mode { Show the question. Have students write down their answers. Show the correct answer.

Option 4. Review ACTIViewer Recording Sheets (15 minutes)

Have student volunteers refer to their completed ACTIViewer recording sheets to make up questions and quiz fellow classmates. When they're through, have students file their ACTIViewer in a notebook or file folder along with the reading passage and related work.

Option 5. Online Research Project (1 hour)

Send students to **www.FreshScience.com/atmos**. Once there, have students follow the directions provided for researching and then reporting on the various ways, other than temperature, that layers of the atmosphere are identified and determined (e.g. composition, ionization, chemical reactions).

Option 6. Unit Assessment (20 minutes)

Have students complete **Part One** of the Unit Assessment (Pages 125-126).

Hands-on Activity Teacher Notes
Mapping Ozone in the Stratosphere

Student Objectives

- Constructing a graph to show ozone data gathered by Nimbus-7 over a 14-year period above various geographical areas on Earth
- Analyzing ozone data to determine where and when ozone is most plentiful, least plentiful, and relatively stable from year to year
- Analyzing ozone data to determine whether ozone levels in the atmosphere vary with the seasons, and if so, how.

Procedure

- First, remind students of your earlier discussion about ozone and that the presence of CFCs in the stratosphere has altered the ozone layer.
- Then, distribute a TOMS activity sheet and a sheet of 11 x 14 graph paper to each student.
- Next, review the TOMS data with students. Explain that these data are derived from the Total Ozone Mapping Spectrometer aboard the Nimbus-7 satellite. This NASA-developed instrument measures ozone indirectly by comparing and mapping incoming UV radiation from the sun to UV radiation scattered from the Earth's atmosphere back to the satellite.

[Note: Here's the technical explanation, which you may or may not choose to share with your students. In other words, this scattered UV radiation is radiation that has penetrated to the Earth's lower atmosphere and then been reflected by air molecules and clouds back through the stratosphere to the TOMS sensors. Along the way, as the UV radiation passes through the stratosphere, the ozone there absorbs a fraction of that radiation. By comparing the amount of radiation reflected back to the TOMS sensors to the amount of incoming solar energy, scientists can calculate the ratio of light reflected by Earth compared to the amount that it receives. This ratio is known as the Earth's albedo. Changes in albedo can be used to derive the amount of ozone above the surface.]

Tell students that the TOMS measures "total column ozone." That's the total amount of ozone in a column of air extending from the Earth's surface to the top of the atmosphere. If the ozone present in the column of air were to be compressed to 0° C and 1 atmosphere pressure (sea level) and spread out evenly over the column's area, it would form a slab, or layer, of a certain thickness. One Dobson Unit (DU) is defined to be 0.01 (one one-hundredth) mm thickness at 0° C and at sea level. So, for example, 300 DU of ozone would be equivalent to a layer 3 mm thick.

Explain that the Dobson Unit is the most basic measure used in ozone research, and is named after G. Dobson, one of the first scientists to investigate atmospheric ozone. You might suggest that students further investigate Dobson's work and report their findings to the class.

- Now focus students' attention on the activity sheet chart. Explain that while the TOMS returns daily ozone data, what is presented in this chart are the highest and lowest levels of ozone for each of 14 years above three different locations on Earth. The day column indicates the day of the year the data was obtained. The ozone values are given in Dobson Units. To check for understanding, you might ask students how many millimeters of ozone equals 496 DU. *[4.96 mm]* 140 DU? *[1.4 mm]* How many DU in 3 mm? *[300 DU]*
- Next, have student volunteers locate and point out Resolute, Canada; Bogota, Columbia; and McMurdo Station, Antarctica on a classroom world map or globe. Which location is nearest the equator? *[Bogota]* The North Pole? *[Resolute]* The South Pole *[McMurdo Station]*?
- Have students plot the data, complete their graphs and answer the questions at the bottom of their activity sheets.

Answers to Questions on Student Activity Sheet

1. Which location had the greatest decline in ozone levels between 1979 and 1992?
   McMurdo Station, Antarctica
2. Which location had the least change in ozone levels from year to year?
   Bogota, Columbia
3. Which location had the greatest range of high and low levels of ozone?
   Resolute, Canada
4. Consider the days that the data were gathered. What conclusions can you draw about ozone minimums and maximums as they relate to months and seasons?
   Maximum values from year to year occurred within a 30- to 60-day span. The same was true for minimum values. The highest and lowest values don't necessarily occur at opposite times in the calendar year. For example, the values at the Antarctica station were lowest in Late September and October and highest in November. In Canada, however, the lowest values typically were found in September and October and the highest values were found in March and April—nearly 6 months apart. At the equator, ozone values were highest in August and September, and lowest in late December through January.
5. When and where are ozone levels lowest on Earth?
   Late September and October in Antarctica
6. When and where are ozone levels highest?
   March and April in northern Canada

Extension

To extend this activity go to **www.FreshScience.com/nimbus**. Click on the link provided to view Nimbus-7 data for many other cities.

A note about the blackline masters that follow

The next 10 pages (pp. 17 – 26) are blackline masters for the Reading, Writing, Thinking and Hands-On Activities, as well as for the ACTIViewer™ recording sheets for this first lesson. In addition to these printed masters, an electronic version of each document in PDF format can be found on the DVD. Adobe Acrobat® is required to view these documents. ScratchCat® authorizes you to print as many copies of the blackline masters as necessary to meet the needs of your class.

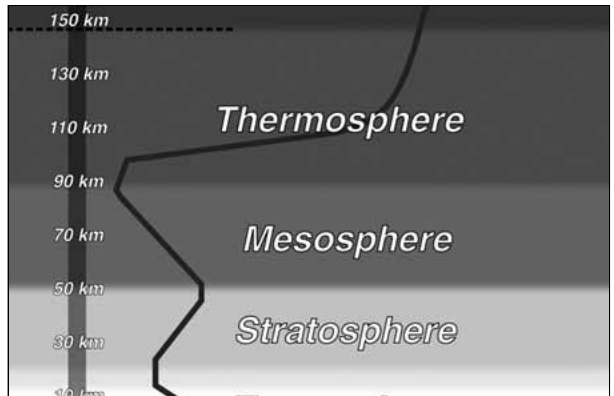
Please note that additional blackline masters appear after each of the four subsequent video lessons in this Teacher's Guide. The same information as outlined above applies to those blackline masters as well.

Reading Activity

Start with: The Atmosphere

What ís the most amazing **weather** you have ever seen? Was it beautiful? Or, was it scary? Planet Earth offers all types of weather. And that weather has a big impact on you. What do you know about the weather? Do you know why we have it? Do you know why it changes? Weather starts in the atmosphere. What do you know about it?

The **atmosphere** is a thin blanket of **air** that surrounds Earth. It extends from the ground up to outer space. Five layers make up the atmosphere. These layers are based mostly on temperature. Each layer has unique features.



Temperatures are nearly 1700° C in the thermosphere.

The atmosphere is a **mixture** of gases. It is 78% nitrogen and 21% **oxygen**. The other 1 percent is made of gases like **water vapor** and argon. Salt, pollen and dust are also in this air.

The lowest layer of the atmosphere is called the **troposphere**. It extends up about 10 kilometers (6 miles) from the ground. At the top of the troposphere, the temperature is a frigid –58° C. Most of the weather happens in this layer.

The **stratosphere** is next. It is about 38 kilometers (23.6 miles) thick. It has steady, level winds and few clouds.

Ozone is a molecule made of three oxygen **atoms**. A layer of ozone floats in the upper stratosphere. Ozone in the troposphere is a problem. But in the stratosphere, ozone is a good thing. Ozone absorbs much of the **ultraviolet radiation** from the sun. In recent years, the amount of ozone in the stratosphere has dropped. People were polluting the air with chlorofluorocarbons (CFCs). Today, the production of CFCs is banned. But it will take many years for ozone levels to return to normal.

At the top of the stratosphere, temperatures return to a mild –2° C. There begins a new layer—the mesosphere. The **mesosphere** is the middle layer. Meteors seen in the night sky are in the mesosphere, most likely. The top of the mesosphere is a bitter cold –90° C. But in the next layer, temperatures warm up again.

The **thermosphere** sits atop the mesosphere. It extends to about 600 kilometers above Earth. At that altitude, the temperature has climbed to nearly 1700° C. Gases in the atmosphere are layered in the thermosphere. And radio signals can be bounced off this layer, also known as the ionosphere.

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Start with: The Atmosphere

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A beautiful feature of the ionosphere is the presence of auroras. Particles from space strike the gases in the ionosphere, causing them to glow. Each gas glows a different color.

The last layer is the **exosphere**. It tapers off into the vacuum of space. The exosphere is as far away as one can get from weather on Earth.

The atmosphere protects our planet. It gives us life. It is the playing field for our weather. In upcoming lessons, youíll return to the troposphere. There, you will find the ingredients for any type of weather you want.

Glossary

air
n. the mixture of gases and tiny particles that make up Earthís atmosphere. Air is 78% nitrogen and 21% oxygen. The remaining 1% consists of many other gases, with argon, carbon dioxide and water vapor among the most plentiful.

atmosphere
n. the gaseous blanket surrounding a planet or star. Earthís atmosphere is mainly nitrogen and oxygen with trace amounts of water vapor, carbon dioxide and argon, among other gases. Earthís atmosphere also contains small particles of salt, pollen and dust.

atom
n. the smallest indivisible unit of an element; an atom can exist alone or can join other atoms to form molecules

exosphere
n. the outermost layer of Earthís atmosphere that eventually trails off into the vacuum of outer space

mesosphere
n. the middle layer of Earthís atmosphere; meso- means middle

mixture
n. a physical combination of two or more kinds of matter

molecule
n. the smallest particle of a substance that retains all the properties of that substance; formed by the joining of two or more atoms

oxygen
n. a colorless, odorless and tasteless element comprising 21% of Earthís atmosphere and also found in water as well as in rocks, minerals and various organic compounds; animals and plants cannot live without oxygen

ozone
n. a molecule, comprised of three oxygen atoms, that exists naturally in the atmosphere but is concentrated in the upper stratosphere at an altitude of about 25 km, and that absorbs much of the ultraviolet radiation coming from space

Writing Activity
Start with: The Atmosphere

Complete your Writing Activity on a separate sheet of paper.

Option 1. Narrative

Think back to the most amazing weather day of your life. Write a story about something that happened to you, a family member or a friend on that day.

Tell a story. Show a sequence of events over time. Portray a clear sense of beginning, middle and end. Tell "all about" events clearly and completely.

Option 2. Informative – "How To"

Tell the steps you would take to make an accurate diagram or model of the atmosphere.

Tell all about how to do something. Elaborate the steps so the reader could replicate the activity. Present a logical sequence of steps. Explain the activity and its steps completely and clearly. Remain on topic from beginning to end.

Option 3. Persuasive

Even though the United States banned the manufacturing of CFCs, other countries have not. Write a letter to the ambassador of a CFC-producing country. Tell him or her why the country should stop making CFCs.

Express your position on a topic. Indicate a position and support that position with reasons. Explain the reasons clearly and completely. Remain on topic from beginning to end

Option 4. Informative – Classification

Many jobs are linked to the weather. Some people make money when the weather is good. Other people make money when the weather is bad. Write about some weather-related jobs in your area. Which benefit from good weather? Which make more money? Which are hardest?

Group ideas clearly into categories . Present both sides of the topic (good/bad or positive/negative); however, there does not have to be a balanced presentation. Present information completely and clearly. Remain on topic from beginning to end.

Name ____________________

Thinking Activity
Start with: The Atmosphere

Choose a question from one of the three options below. Write your response in the space provided.

Option 1. Analysis

What is the difference between the troposphere and the stratosphere?

Option 2. Synthesis

What if the United States lifted the ban on CFC production?

Option 3. Evaluation

Which layer of the atmosphere do you like best? Why?

Hands-on Activity
Mapping Ozone in the Stratosphere

Background

The Total Ozone Mapping Spectrometer (TOMS) aboard the Nimbus-7 satellite makes 35 measurements every 8 seconds. That's about 200,000 daily measurements to cover nearly every single spot on Earth. Each measurement covers an area that's 50 to 200 kilometers (30 to 125 miles) wide. Nimbus-7 data, combined with Meteor-3 TOMS data, form a complete data set of daily ozone levels in the stratosphere from November 1978 through December 1994.

Materials

1 sheet 11 X 14 graph paper, three pens—each a different color

Procedure

- First, orient your graph paper so that the short sides are at top and bottom (portrait mode).
- Label your graph so that anyone looking at it would know it shows minimum and maximum ozone levels in the stratosphere for the years 1979-1992.
- To construct your graph, label the Y axis Dobson Units—start your numbering at the bottom with 130 and mark off in increments of 10 to 590 at the top.
- Make your X axis years, starting with 1979 at left and labeling by consecutive years to 1992 at right.
- Next, plot the 14 years of data from the three geographic locations given on Page 2. Use a unique color for each location so that the data are easy to compare.
- Finally, refer to your completed graph as you answer the questions below.

Questions

Write your responses on a separate sheet of paper.

1. Which location had the greatest decline in ozone levels between 1979 and 1992?
2. Which location had the least change in ozone levels from year to year?
3. Which location had the greatest range of high and low levels of ozone?
4. Consider the days that the data were gathered. What conclusions can you draw about ozone minimums and maximums as they relate to months and seasons?
5. When and where are ozone levels lowest on Earth?
6. When and where are ozone levels highest?

Nimbus-7 Total Ozone Mapping Spectrometer (TOMS) Overpass data* for three sites

1 RESOLUTE, CANADA – 74.72° NORTH LATITUDE, 94.98° W LONG

Year	Day	TOMS Lowest value	Day	TOMS Highest value
1979	286	260.4	059	569.8
1980	282	247.2	099	553.9
1981	283	238.0	105	541.9
1982	268	252.5	093	574.3
1983	244	257.7	094	541.9
1984	283	226.7	060	549.3
1985	253	240.8	097	546.4
1986	262	248.6	087	526.5
1987	286	240.9	097	524.7
1988	268	247.2	094	546.2
1989	274	254.1	059	585.5
1990	268	267.0	077	504.4
1991	262	240.1	083	548.3
1992	242	258.5	092	496.4

2 BOGOTA, COLUMBIA – 4.51° N LATITUDE, 74.08° W LONGITUDE

Year	Day	TOMS Lowest value	Day	TOMS Highest value
1979	032	229.9	243	284.1
1980	008	234.9	244	297.1
1981	363	225.8	244	283.0
1982	020	230.0	239	297.2
1983	362	225.1	221	279.7
1984	019	227.5	272	276.7
1985	016	237.3	233	288.4
1986	365	228.6	245	277.3
1987	036	216.4	241	290.3
1988	346	234.4	212	279.0
1989	011	234.6	260	284.0
1990	358	236.2	248	300.9
1991	347	223.9	249	284.3
1992	016	224.8	239	287.1

* in Dobson Units (DU)

3 MCMURDO STATION, ANTARCTICA – 77.90° S LATITUDE, 166.70° E LONGITUDE

Year	Day	TOMS Lowest value	Day	TOMS Highest value
1979	249	266.9	306	452.7
1980	304	231.7	322	440.0
1981	291	239.3	327	439.0
1982	308	216.9	279	408.7
1983	291	205.7	312	424.1
1984	263	216.2	308	424.3
1985	290	171.7	306	437.8
1986	294	188.7	318	428.8
1987	274	148.2	334	399.0
1988	266	208.8	308	465.3
1989	276	172.4	305	385.2
1990	282	149.1	314	368.0
1991	284	148.8	323	433.4
1992	272	164.6	296	406.6

* in Dobson Units (DU)

Name ____________________

ACTIViewer™
Start with: The Atmosphere

1. Define weather. ____________________

2. What tools are used to measure weather?

Tool	Measures

3. Define climate. ____________________

4. What do you call a scientist who studies climate and weather? ____________________

5. Show the composition of Earth's atmosphere.

Nitrogen

Oxygen

Other gases

6. Show the layers of Earth's atmosphere based on temperature and altitude.

7. Draw an ozone molecule. Show its interaction with chlorine.