

Environmental Literacy Framework

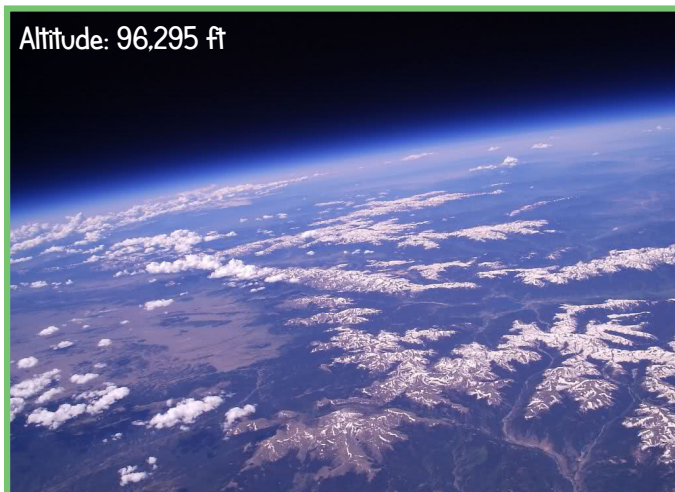
Stacking up the Atmosphere

Preview

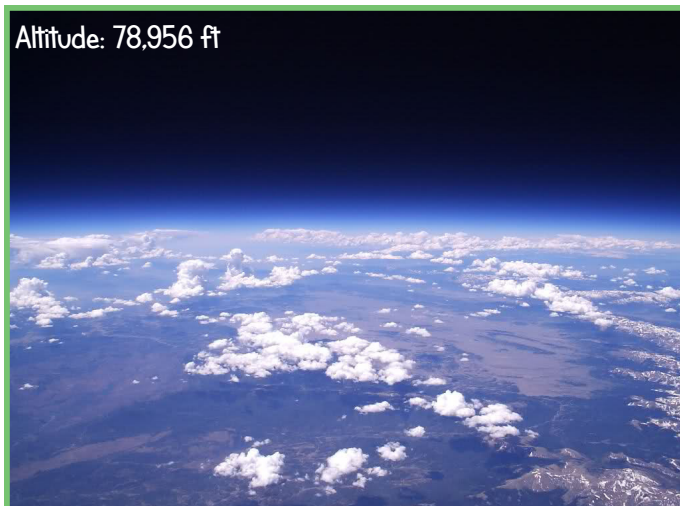
Focus Question:

If you could take off from Earth's surface in a rocket, how would the atmosphere change as you went up through it toward outer space?

NOAA (National Oceanic and Atmospheric Administration) studies the Earth's atmosphere. The images below are from a camera which was attached to a weather balloon and launched into space.



This shot was taken near the top of the flight. It shows the snowcapped mountain tops near Middle Park and Georgetown, Colorado. The curvature of the earth is visible on the horizon.



This picture (actually from the balloon's descent) shows many clouds, including developing thunderheads.

Photos: Allen Franklin Jordan, NOAA

Unit-5 Atmosphere



Time

1 class period

Materials:

- Atmosphere insert
- Tennis ball containers
- Atmosphere layer strip cut from "Layers of the Atmosphere Chart"
- Magnets
- Tape
- Scissors
- Magnetic surface

Vocabulary (Terms)

Aurora
Blue Sprites
Elves
Ionosphere
Jets
Mesosphere
Meteor
Noctilucent clouds
Ozone
Stratosphere
Stratocumulus
Thermosphere
Troposphere



Activity 5A- Stacking up the Atmosphere

Prepare

Build a Model of an Atmospheric Column

Materials:

- Atmospheric Layer Insert
- Atmosphere strips (cut from Layers of the Atmosphere Chart)
- Colored pencils or Markers
- Clear Plastic Tennis Ball Cans (1 per person)
- or Clear Plastic Florescent Light Tubes (available at most hardware stores)
- Ruler
- Scissors
- Tape

Activity Steps:

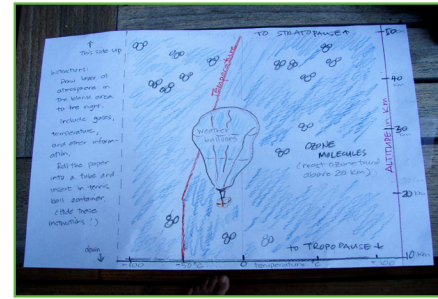
1. Divide into groups of five. Each person in the group will choose, or be assigned, one layer of the atmosphere.

2. Use information from the Layers of the Atmosphere Chart (and any other available resources) to make a creative illustration of your assigned layer. Draw it on the Atmospheric Layer Insert sheet provided.

Make sure your illustration includes:

- The name of your layer
- Names of the layers that are above and below your layer
- Red line indicating how temperature changes as altitude increases (use the scale at the bottom of the insert)
- Drawings of events, objects and phenomena found within your layer
- Altitudes of the upper and lower boundary of your layer

(NOTE: Though the cylinders are all of equal height, the layers they represent are of differing thicknesses. If you want to build a model of the atmosphere to the correct vertical scale, you will need to calculate the height of each layer as a percentage of your total column height).



Above: Diagram drawn out before rolling and inserting in tube.

Atmosphere Layer Chart on next page.
Insert and Atmosphere chart- on page 133-34.




This is a diagram of the stratosphere - Front of tube.



-Back of tube

Layers of the Atmosphere Chart

(all values are estimates)

(Cut apart layer strips on the dotted line.) 

Name of layer	Altitude range	Temperature range	Description of gases	Percentage of the atmosphere's total mass	Events/Objects/Phenomena
Exosphere (exo = outside)	500-10,000 km	Temperature decreases with altitude, dropping from ~1500 down to -270°C	Ionized gases and molecules, some of them escaping from Earth's gravity	Very much less than 1%	Polar-orbiting satellites; Earth's gravitational influence gradually diminishes as this layer transitions to "outer space."
Thermosphere (thermo = heat)	80-500 km	Temperature increases with altitude from -90 up to ~1500°C	Light molecules such as hydrogen, interacting with high-energy solar radiation	Much less than 1%	Space Shuttles (~250 km), International Space Station (~330 km); auroras; ELVES (expanding discs of light associated with some thunderstorms)
Mesosphere (meso = middle)	40-80 km	Temperature decreases with altitude from 0 to -90°C	Mainly nitrogen and oxygen, with fewer and fewer particles as altitude increases	Under 1%	Majority of meteors burn up in this layer; noctilucent (night-shining) clouds of water ice; sprites (jellyfish-shaped flashes of red light associated with some thunderstorms)
Stratosphere (strato = layer)	10-40 km	Temperature increases with altitude from -60 to 0°C	Nitrogen, oxygen, and other gases, including the ozone "layer" (Greatest abundance of ozone is at about 20 km)	19%	Weather balloons, high-altitude research aircraft, some commercial jet flights; blue jets (cones of blue light that project from the top of some thunder clouds), cooling over time as less heat escapes from troposphere
Troposphere (tropo = changing)	0-10 km	Temperature decreases with altitude from 20 to -60°C	Nitrogen, oxygen, argon, carbon dioxide, water vapor, and others	80%	Gases moving between land, ocean, life, and air; airborne particles of dust or soot; weather systems; planes; layer is warming over time due to increases in heat-trapping gases

Activity 5A- Stacking up the Atmosphere

Practice (Assessment): Card sort / matching activity

1. Cut a copy of the Layers of the Atmosphere chart into the separate boxes (omit the column headings and row names).
Optional: You may choose to tape or glue each box of text to a 3" x 5" inch card so they are all the same size.
If you have a magnetic surface such as a white board available, you could also put magnets on the back of each card.
2. List the layers of the atmosphere in the correct order along the left side of the area where you'll rebuild the chart.
3. Individuals take one box of text at a time and describe the information to the class. Then, they place the card next to the appropriate layer name.

Ponder

1. Some satellite instruments measure the amount of specific types of gases within a column of the atmosphere. Describe how your model can help people understand what is meant by the phrase "total column ozone."
2. The name of each layer of the atmosphere is named with a specific prefix with the suffix "-sphere." Describe why each layer is called a sphere.
3. Come up with a way to help you remember the names of the layers in the correct order.
4. Calculate where the top and bottom of each layer would be if a 100 yard football field represents the height of the entire atmosphere. (Hint: Use ratios for each level by making 100 yards equivalent to 10,000 km). Example $10/10,000 = x/100$

Present

Practice giving a brief description of each of the five layers of the atmosphere to someone else. Tell which layers are most important in controlling Earth's climate and why.

This end up



Cut out insert on the solid border.



To

Atmospheric Layer Insert

Instructions:

Illustrate your assigned layer of the atmosphere and include:

- The name of layer
- Names of the layers that are above and below your layer
- Red line indicating how temperature changes as altitude increases (use scale at the bottom of the insert)
- Drawings of events, objects and phenomena found within your layer
- Altitudes of the upper and lower boundary of your layer

Note: roll your illustration up, overlapping to hide these directions. Then insert it into an empty tennis ball can.

Altitude in Kilometers

To



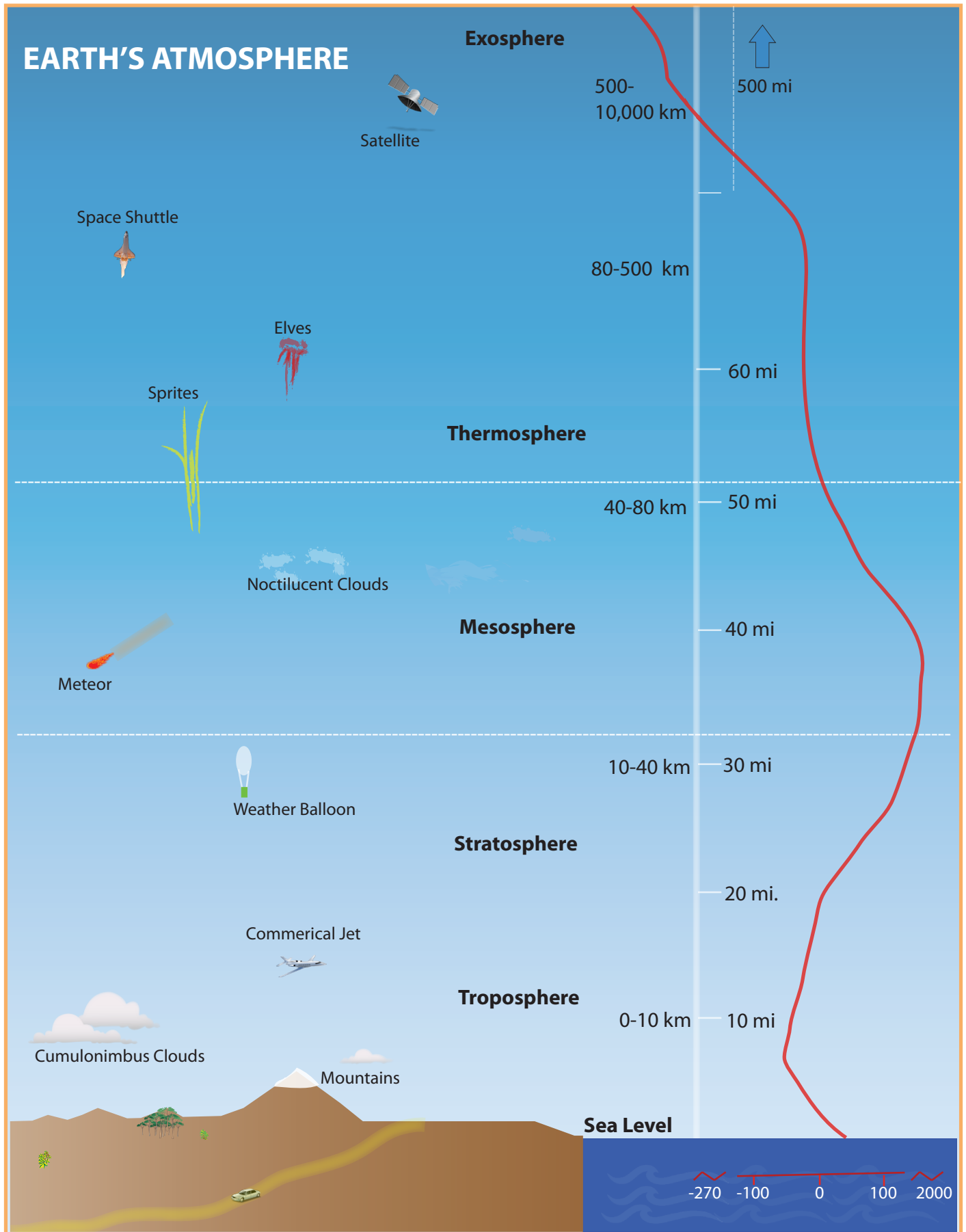
-270°C

-100°C

0°C

100°C

+2000°C



Graphic: Rita Thomas, ANDRILL Science Management Office

Stacking up the Atmosphere

Background Information for the Teacher

Activity	NSES 5-8	CLEP	ELF
<p>Stacking Up the Atmosphere In this hands-on activity, participants learn the characteristics of the five layers of the atmosphere and make illustrations to represent them. They roll the drawings and place them in clear plastic cylinders, and then stack the cylinders to make a model column of the atmosphere.</p>	<p>Content Standard F: The atmosphere is a mixture of nitrogen, oxygen, and trace gases that include water vapor. The atmosphere has different properties at different elevations.</p>	<p>CLEP2A: Earth's climate is influenced by interactions involving the Sun, ocean, atmosphere, clouds, ice, land and life. Climate varies by region as a result of local differences in these interactions. CLEP2C: The amount of solar energy absorbed or radiated by Earth is modulated by the atmosphere and depends on its composition.</p>	<p>Atmosphere 1a,b, & c: The atmosphere is a mixture of gases with small, but important, quantities of liquid and solid particles. The composition of the atmosphere affects the amount of solar energy received, and has changed over time. Atmosphere 3 a, b & c: Earth's atmosphere is composed of a series of layers that vary in composition, density, and temperature with height above them Earth's surface.</p>

NSES: National Science Education Standards (<http://www.csun.edu/science/ref/curriculum/reforms/nses/index.html>)

CLEP: Climate Literacy Essential Principles (<http://www.climatescience.gov/Library/Literacy/>)

ELF: Environmental Literacy Framework (www.andrill.org/education/elf)

For more information:

<http://www.windows2universe.org/earth/Atmosphere/layers.html>

<http://www.srh.noaa.gov/jetstream//atmos/layers.htm>

The Troposphere

• Of the five layers of our atmosphere, the troposphere is where most of the weather takes place. This is because the troposphere is warmed by radiation from the Earth's surface. Energy from the Sun is absorbed by the land and water, re-radiated back into the atmosphere and then trapped by the gases in the air. Due to the uneven heating of the Earth's surface, winds are formed by the rising and falling of warm and cool air masses.

Activity 5A- Stacking up the Atmosphere

- Most of the water vapor and dust particles occur here as well, so this is where clouds form. The movement of air distributes heat and water vapor around the surface of the Earth.
- The average global temperature of the atmosphere near the surface is 62°F (17°C).
- Near the poles, the troposphere is about 4 miles (7 km) high and near the Equator about 12 miles (20km) high. The troposphere cools to about -64°F (-55°C) near the top.
- The jet stream is near the top of the troposphere. This "river of air" influences weather patterns around the globe as it moves along at 250 mph (402 kph).
- About 80% of the mass of the atmosphere is found in this first layer of the atmosphere. Above this level the particles of gases become much less dense.

The Stratosphere and Ozone Layer

- Above the troposphere is the stratosphere which contains about 19% of the atmospheric gases. Starting at the top of the troposphere, it ends around 31 miles (50km) above the Earth's surface.
- In the stratosphere, a thin layer of ozone molecules protects the Earth by absorbing ultraviolet (UV) radiation from the Sun. In recent years, manmade compounds (fluorocarbons) have been damaging the ozone layer which may have consequences for life on the Earth. UV radiation is harmful to many life forms on Earth. As you move up through the stratosphere the temperature increases from -64°F (-51°C) to about 5°F (-15°C) near the top.
- Ozone molecules absorb the UV radiation from the Sun heating up this layer. This increase in temperature reduces the mixing of air masses so the stratosphere is a very stable layer. It also contains very little water vapor so few clouds form here.
- The top of anvil-shaped thunderheads are formed at the lower limits of the stratosphere because the cool air comes in contact with the warmer air and will not rise any further.
- Commercial jets frequently fly in the lower stratosphere to avoid turbulence from the winds and clouds in the troposphere. Air is about a thousand times thinner near the top of the stratosphere than it is near the Earth's surface. Because of the thinner air, jet aircraft and weather balloons reach their maximum flight altitudes within the stratosphere.
- Polar stratospheric clouds (PSCs) form near the poles in winter when temperatures in the stratosphere dip below -108° F (-78° C). Chemical reactions occur in these clouds that appear to destroy ozone. PSCs are also called nacreous clouds.
- Volcanic eruptions and meteorite impacts increase particles in the stratosphere where they may linger for months or years due to this stable layer of air. These particles have been known to alter the Earth's global climate.
- "Blue jets" are a rare type of electrical discharge, similar to lightning. They appear above thunderstorms, extending through the stratosphere up to altitudes of 25 to 31 miles (40 and 50 km).

Stacking up the Atmosphere

Mesosphere

- Beginning above the stratosphere, the mesosphere extends up to 53 miles (85 km) high, and the temperature drops again to around -130°F (-90°C).
- The mesosphere is hard to study, so scientists know less about this layer. Because of the very thin air, weather balloons and planes cannot operate, and the orbits of satellites are above the mesosphere.
- We do know that most meteors coming from space burn up in this layer.
- A unique type of cloud known as "noctilucent clouds" form near the poles in the mesosphere.
- In this layer there are odd types of lightning, called sprites and ELVES, which appear dozens of miles above thunderclouds sitting in the troposphere below.

Thermosphere

- Directly above the mesosphere is the thermosphere. It extends to between 311 to 621 miles (500 and 1,000 km) above the Earth.
- Temperatures again heat up in the lower thermosphere below 124- 186 mi (200-300 km), then hold steady as the altitude increases above that height. Solar activity strongly influences temperature in the thermosphere which is typically 360°F (200°C) hotter during the day than at night, and roughly 900°F (500°C) hotter when the Sun is in an active period. Temperatures in the upper thermosphere range from 932°F (500°C) to $3,632^{\circ}\text{F}$ ($2,000^{\circ}\text{C}$) and have been known to be higher. Temperature is a measure of kinetic energy of molecules. Heat is the total kinetic energy of a given quantity of something. While each molecule of gas in this layer may have extremely high kinetic energy, overall this layer would not feel "hot" to us. This is because there are almost no molecules of gas in the layer. In fact, an astronaut would freeze to death if exposed to this region of the atmosphere.
- Because the air density in the thermosphere is so low, we normally think of this layer as outer space. The orbits of both the space shuttle and the International Space Station are within the thermosphere.
- When the Sun is very active and emitting more high energy radiation, the thermosphere heats up and expands causing the top of the thermosphere to vary in height. Changes in the density of this very, very thin air can cause problems for orbiting satellites. Heating and expansion of the thermosphere generates a drag force on the satellites creating a problem for engineers who must take this into account when calculating orbit height.
- Both the Southern and Northern Lights (auroras) occur primarily in the thermosphere. Charged particles (electrons, protons, and other ions) coming from space collide with air particles in the thermosphere in the polar regions, exciting them into higher energy states. When the particles shed this added energy, light is emitted which we see as the colorful auroral displays. Most of the auroras happen in this layer.

Activity 5A- Stacking up the Atmosphere

Exosphere

- On top of the thermosphere, the atmosphere is very thin and many air particles escape to outer space. The layer is known as the exosphere and extends to 6200 miles (10,000km) above the Earth.
- The region where atoms and molecules escape into space is referred to as the exosphere. Many satellites orbit in this layer.

Ionosphere

In this activity we are not making a distinction between this region and the other layers.

- The ionosphere is not a distinct layer, but rather it is a region of the outer atmosphere that includes parts of the mesosphere, thermosphere and exosphere. (NOTE: In this activity's model, students could represent the ionosphere by wrapping plastic wrap or colored cellophane around the top three cans representing the mesosphere, thermosphere, and exosphere layers.).
- In this area, the Sun's energy is so strong that it breaks apart particles creating molecules which have lost or gained electrons (ions) as well as free-floating electrons. More ionization occurs during periods when the Sun is active and during the day when the angle of the sun is high.
- Long distance radio communication is made possible by reflecting the radio waves back to Earth from the ionosphere.
- This region is where ionization takes place, and it is this process that produces the auroras. (see "thermosphere")

Gases of the Atmosphere.

- In the lower atmosphere, the air is mainly composed of the familiar blend of about 80% nitrogen molecules (N_2) and about 20% oxygen molecules (O_2).
- Below the thermosphere, gases are constantly mixed by the turbulence of winds in the atmosphere.
- Above the thermosphere, gas particles are widely separated and collide infrequently. High energy ultraviolet and X-ray waves from the Sun break apart molecules in the thermosphere. Atomic oxygen (O), atomic nitrogen (N), and helium (He) are the main components of air in this layer.

Glossary

Stacking Up the Atmosphere	Aurora	Sometimes called "Polar Lights," these light displays usually are observed in the sky above the Polar Regions. Earth is the constant recipient of the solar wind. Auroras are caused by collisions of charged particles from the solar wind and Earth's magnetic field. In the Arctic, these lights are called the <i>Aurora Borealis</i> or Northern Lights, while in Antarctica they are the <i>Aurora Australis</i> or Southern Lights.
Stacking Up the Atmosphere	Blue jets	Cones of blue light that project from the top of some thunder clouds. Blue jets are mainly found in the stratosphere.
Stacking Up the Atmosphere	Elves	Expanding discs of light associated with some thunderstorms. Elves are mainly found in the thermosphere.
Stacking Up the Atmosphere	Heat	The total kinetic energy of a given quantity of something
Stacking Up the Atmosphere	Ionization	The process in which an atom or molecule is converted to an ion. The process removes or adds a charged particle such as an electron or other ion.
Stacking Up the Atmosphere	Ionosphere	Part of the upper atmosphere, the ionosphere overlaps with the thermosphere and mesosphere. This layer is where particles are ionized by incoming radiation from the sun.
Stacking Up the Atmosphere	Mesosphere	The layer above the stratosphere and below the thermosphere. The atmosphere here is very thin, and the temperature decreases with altitude.
Stacking Up the Atmosphere	Meteor	A meteor can be seen when a solid object (meteoroid) enters Earth's atmosphere. Meteors usually occur when they enter the mesosphere.
Stacking Up the Atmosphere	Noctilucent Clouds	Noctilucent clouds are the highest clouds in Earth's atmosphere and are located in the mesosphere. They are made up of ice crystals.
Stacking Up the Atmosphere	Ozone	Ozone is a form of oxygen made up of three atoms of oxygen rather than the usual two. It forms a protective layer high up in the stratosphere that reflects some of the ultraviolet (UV) radiation from the sun. Too much UV radiation can cause health problems.
Stacking Up the Atmosphere	Solar Wind	A current of hot plasma (ionized gas) flowing from the sun in all directions.
Stacking Up the Atmosphere	Sprites	Jellyfish-shaped flashes of red light associated with some thunderstorms. Sprites are mainly found in the mesosphere.
Stacking Up the Atmosphere	Stratocumulus	Stratocumulus clouds are usually large and rounded. They seldom produce precipitation, but often indicate that a storm is coming.
Stacking Up the Atmosphere	Stratosphere	The layer above the troposphere and below the mesosphere. The ozone layer is located here and temperature increases slightly with altitude.
Stacking Up the Atmosphere	Temperature	A measure of kinetic energy of molecules.
Stacking Up the Atmosphere	Thermosphere	The layer above the mesosphere and below the exosphere. The gases in the thermosphere are very spread out and the temperature increases with altitude.
Stacking Up the Atmosphere	Troposphere	This is the lowest layer of the atmosphere and where weather occurs.