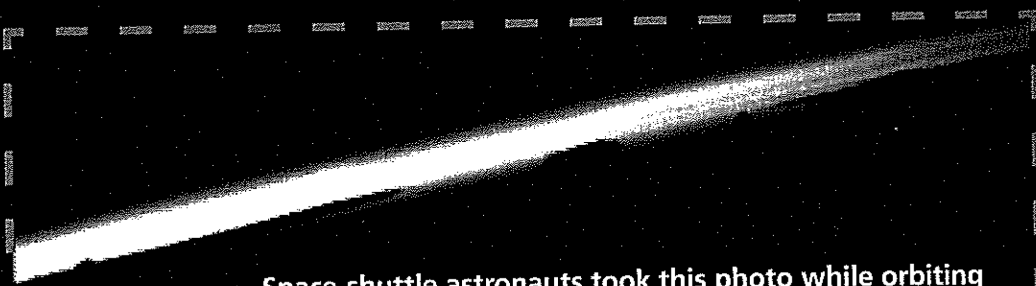
A Thin Blue Veil



Space-shuttle astronauts took this photo while orbiting Earth. You can see a side view of Earth's atmosphere. The black bumps pushing into the troposphere are tall cumulus clouds.

The crew of Apollo 17 took this photograph of Earth in December 1972, while on their way to the Moon. The small box at the top of this photo shows an area equal to the atmosphere photo above taken by space-shuttle astronauts.

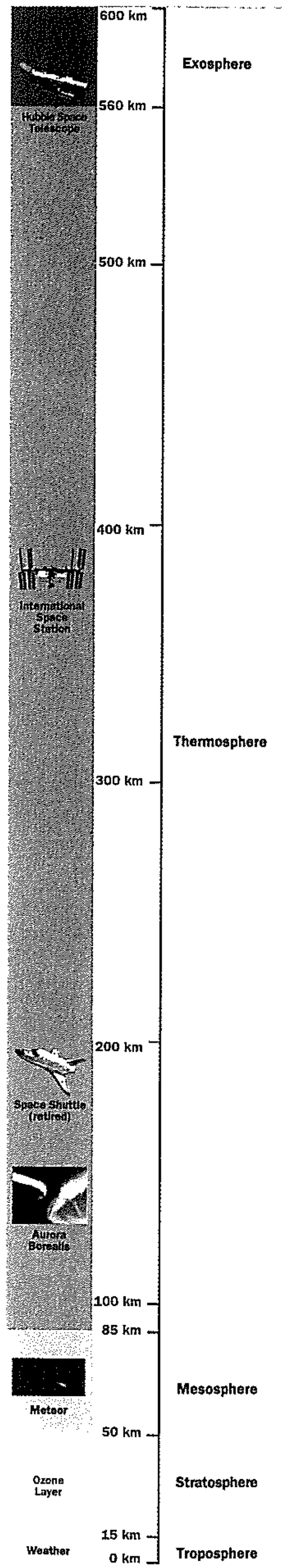
It is cold in deep space. The temperature is in the neighborhood of –270 degrees Celsius (°C). That's nearly 200°C colder than it has ever been on Earth. Near stars, like the Sun, it's outlandishly hot, reaching thousands of degrees. There are, however, a few places here and there in the universe where the temperature is between the extremes. Earth is one of those places. The average temperature on Earth is not too hot and not too cold, just right for supporting life.

On a typical day, the temperature range on Earth is only about 100°C, from maybe 45°C in the hottest place to –55°C at one of the poles. The extremes are 57°C in Furnace Creek Ranch, Death Valley National Park, California, recorded on October 7, 1919, and –89°C in Vostok, Antarctica, on July 21, 1983. That's a range of temperature on Earth of 146°C.

It's not only because we are at the right distance from the Sun that Earth has tolerable temperatures. Earth's atmosphere keeps the temperature within a narrow range that is suitable for life.

From space, Earth's atmosphere looks like a thin blue veil. Some people call it an ocean of air. The depth of this "ocean" is about 600 kilometers (km). The atmosphere is most dense right at the bottom where it rests on Earth's surface. The air gets thinner and thinner (less dense) as you move away from Earth's surface, until it disappears.

Imagine a column of air that starts on Earth's surface and extends up 600 km to the top of the atmosphere. Scientists have discovered several distinct layers in this column of air. Each layer has a different temperature. Here's how it stacks up.

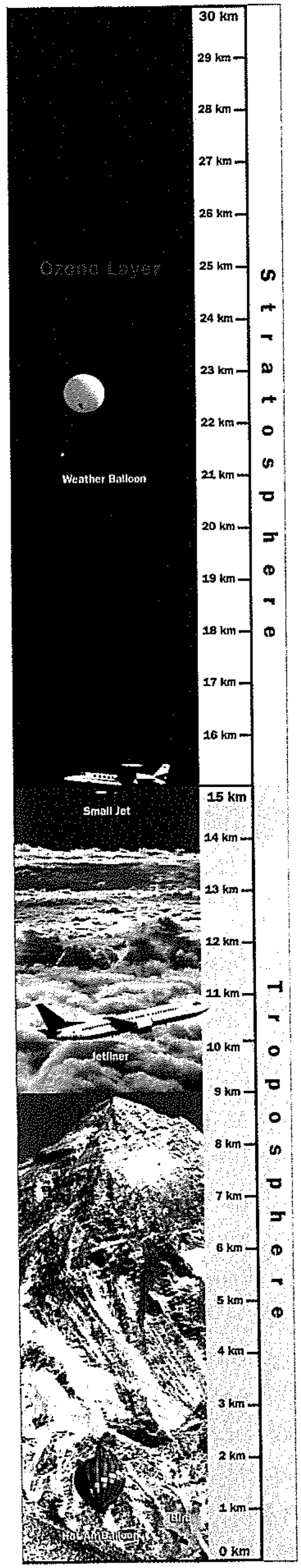


Earth's atmosphere

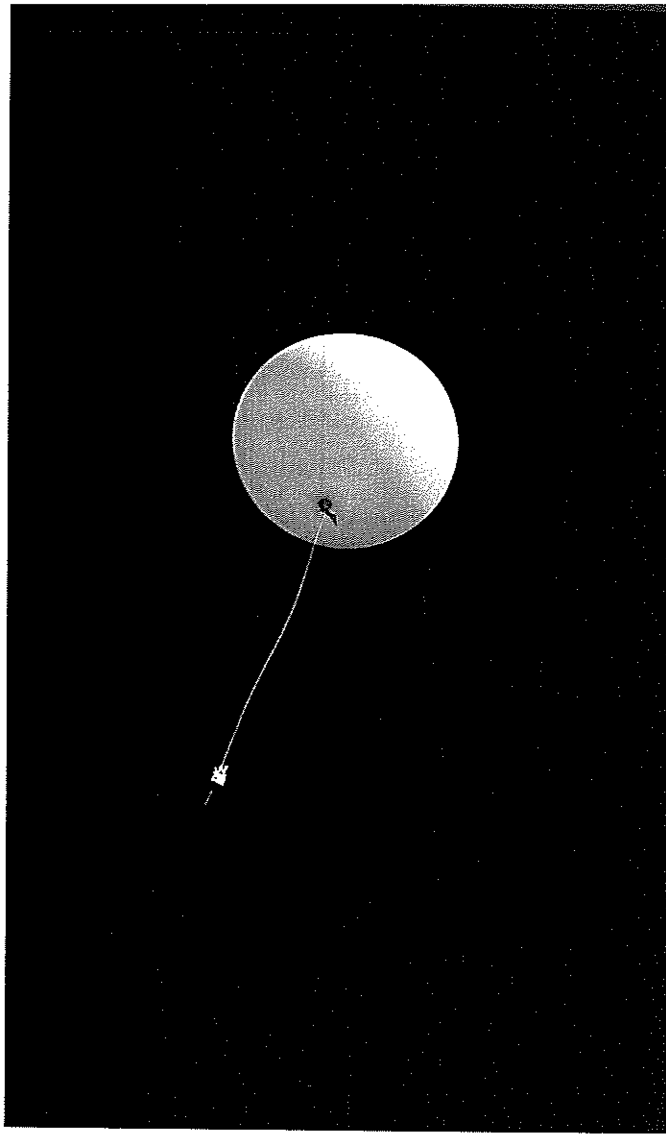
The layer we live in is the **troposphere**. It starts at Earth's surface and extends upward for 10–24 km. Its thickness depends on the season and where you are on Earth. Over the warm equator, the troposphere is a little thicker than it is over the polar regions, where the air is colder. It also thickens during the summer and thins during the winter. A good average thickness for the troposphere is 15 km.

This ground-floor layer contains most of the organisms, dust, water vapor, and clouds found in the entire atmosphere. For that matter, it contains most of the air as well. And most important, weather happens in the troposphere. The troposphere is where the action is. This is where differences in air temperature, humidity (moisture), air pressure, and wind occur.

Weather occurs in the troposphere.



The first 30 km of the atmosphere



Weather balloons are launched to monitor temperature, humidity, air pressure, and wind.

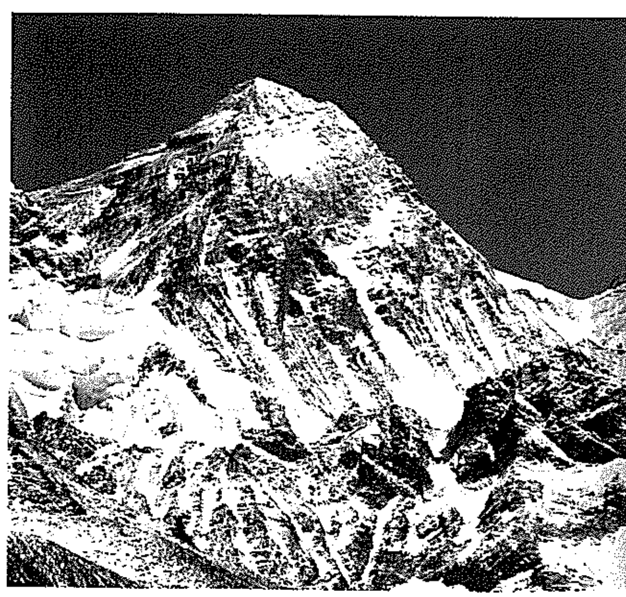
These properties of air temperature, humidity, air pressure, and wind are called **weather factors**. Meteorologists launch weather balloons twice a day to monitor weather factors. The balloons float up through the atmosphere to about 23 km. Weather factors will be investigated in detail as we continue to study weather.

The troposphere is the thinnest layer, only about 2 percent of the depth of the atmosphere. It is the most dense layer, however, containing four-fifths (80 percent) of the total mass of the atmosphere.

Earth's surface (land and water) absorbs heat from the Sun and warms the air above it. Because air in the troposphere is heated mostly by Earth's surface, the air is warmest close to the ground. The air temperature drops as you go higher. At its upper limit, the temperature of the troposphere is about –60°C. The average temperature of the troposphere is about 25°C.

Mount Everest, located in Nepal and Tibet, is the highest landform on Earth, rising 8.8 km into the troposphere. The air temperature at the top of the mountain is well below freezing most of the time. There is also less air to breathe at the top of Mount Everest. Climbers usually bring oxygen along to help them survive the thin air.

The stratosphere is the layer above the troposphere. It is 15–50 km above Earth's surface and contains almost no moisture or dust. It does, however, contain a layer of ozone (O_3), a form of oxygen, that absorbs high-energy ultraviolet (UV) radiation from the Sun. The temperature stays cold until you reach the upper reaches of the stratosphere, where energy absorption by ozone warms the air to about 0°C.



Mount Everest

The **jet stream**, a fast-flowing river of wind, travels generally west to east in the region between the lower stratosphere and the upper troposphere. Many military and commercial jet aircraft take advantage of the jet stream when flying from west to east.

The **mesosphere** is above the stratosphere, 50–85 km above Earth's surface. The temperature plunges again, reaching its coldest temperature of around −90°C in the upper mesosphere. This is the layer in which meteors burn up while entering Earth's atmosphere, producing what we call shooting stars.

Beyond the mesosphere, 85–560 km above Earth, is the **thermosphere**. The thermosphere is the least-understood layer of the atmosphere and the most difficult to measure. The air is extremely thin. The thermosphere is the region of the atmosphere that is first heated by the Sun. A small amount of energy coming from the Sun can result in a large temperature change. When the Sun is extra active with sunspots or solar flares, the temperature of the thermosphere can surge up to 1,500°C or higher!

Within the thermosphere are regions noted for their chemistry properties. These regions contain a large number of electrically charged ions. Ions form when intense radiation from the Sun hits particles in the atmosphere. These ionized particles are responsible for the aurora borealis, or northern lights, and the aurora australis, or southern lights.

The identification of these four layers (troposphere, stratosphere, mesosphere, and thermosphere) is based on temperature. There are no sharp boundaries or abrupt changes in gas composition between them. As average temperatures change with the seasons, the boundaries between layers may move up or down a little.

The Northern lights (aurora borealis)

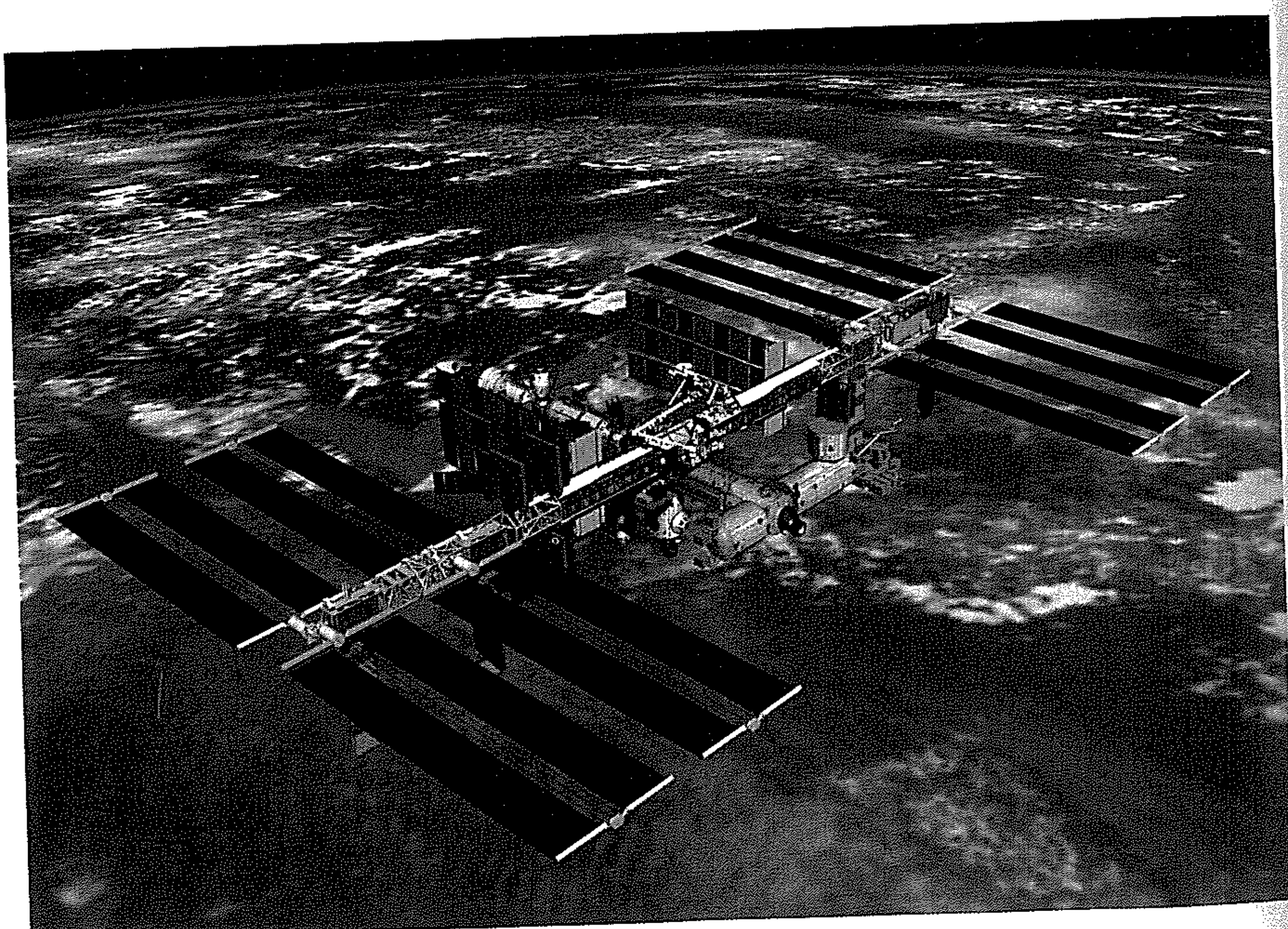
Beyond the thermosphere, Earth's atmosphere makes a transition into space. This area is the **exosphere**, where particles from the atmosphere escape into space. It extends from the top of the thermosphere up to 10,000 km. In this region, the temperature plunges to the extreme –270°C of outer space, and the concentration of atmospheric gases fades to nothing.

That 600 km column of air that makes up the atmosphere pushes down on the surface of Earth with a lot of force. We call this force air pressure, or atmospheric pressure. We are not aware of it because we are adapted to live under all that pressure, but there is a mass of about 1 kilogram (kg) pushing down on every square centimeter of surface on Earth.

Here's another way to look at it. If all the mass of the air were replaced with solid gold, the entire planet would be covered by a layer of gold a little more than half a meter deep. That's a lot of gold, but the atmosphere is much more valuable.

Think Questions

1. How is Earth's atmosphere like the ocean? How is it unlike the ocean?
2. Why do you think airplanes don't fly high in the stratosphere?



The International Space Station orbits in the thermosphere.