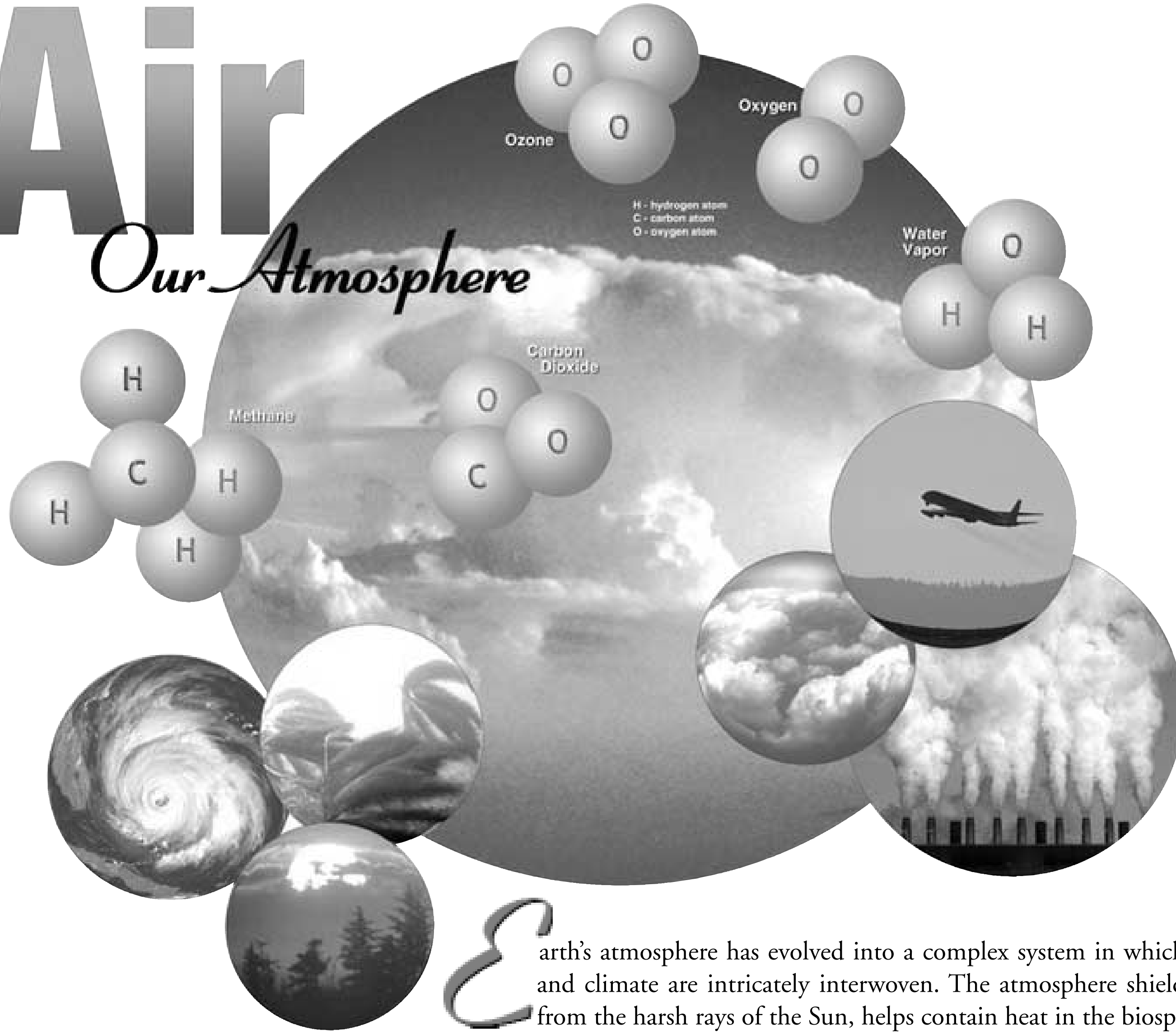
Air
Our Atmosphere



Earth's atmosphere has evolved into a complex system in which life and climate are intricately interwoven. The atmosphere shields us from the harsh rays of the Sun, helps contain heat in the biosphere, and nourishes life on Earth. Because of the complexity and ever-changing conditions in the atmosphere, scientists aren't sure of the net effect that clouds and aerosols (solid and liquid molecules suspended in the atmosphere) have on reducing the Sun's energy at the surface.

The atmosphere is composed of many gases, some of which trap heat and are commonly called greenhouse gases. Examples are carbon dioxide (CO_2), methane (CH_4), and water vapor (H_2O). Also, ozone (O_3) in the upper atmosphere is a gas that reduces the amount of the Sun's ultraviolet radiation that reaches Earth's surface, but if present in high amounts in the lower atmosphere (troposphere), can pose a health threat.

In the past 100 years, human activity has altered fundamental elements of the biogeochemical cycles of the Earth. For example, since 1850, atmospheric carbon dioxide levels have increased by about 30%, and atmospheric methane by more than 100%. It also appears that the troposphere's capacity to clean itself of these greenhouse gases has decreased during the same period. This could lead to a more rapid accumulation of certain gases.

The study of these atmospheric processes can help lead us to a better understanding of the cause-and-effect relationship between humans and the atmosphere.

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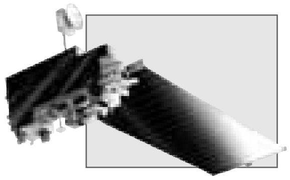
Our Atmosphere — A Mission Sampler



Terra Mission

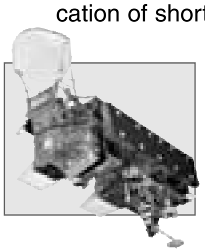
The Terra mission, launched in December 1999, carries five instruments, four of which provide significant contributions to air studies: the Moderate Resolution Imaging Spectroradiometer (MODIS), Clouds and the Earth's Radiant Energy System (CERES), Multi-angle Imaging Spectroradiometer (MISR), and Measurements of Pollution in The Troposphere (MOPITT).

CERES provides global observations of clouds and radiation and data for evaluating the impact of natural events on our climate, i.e., aerosols from the Mount Pinatubo eruption altered the Earth's radiation, causing a cooling of the Earth's atmosphere by 0.5° to 1.0°C (0.9° to 1.8°F).

MISR measures the amount of sunlight scattered in different directions under natural conditions. As the instrument flies overhead, Earth's surface is successively imaged by nine cameras. Because of its different viewing angles, MISR can differentiate between various types of clouds, particles and surfaces enabling scientists to determine global aerosol amounts with unprecedented accuracy.

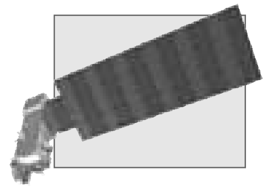
MODIS provides a comprehensive series of global observations every two days at spatial resolutions as fine as 250 meters (820.2 feet). It provides data to monitor clouds and aerosols. Aerosol particles play a critical role in the cloud formation process serving as "seeds" for attracting condensation. MODIS also provides information on temperature and moisture profiles and columnar water vapor in the atmosphere.

MOPITT continuously scans the atmosphere to provide the first long-term, global measurements of carbon monoxide and methane in the lower atmosphere. These data will be used to understand the long-term effects of pollution, determine how increases in ozone affect the lower atmosphere, and guide the evaluation and application of shorter-term pollution controls.



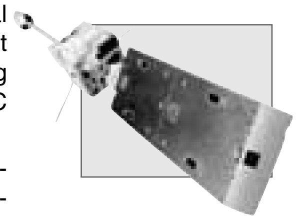
Aqua Mission

AIRS, AMSU, HSB, and AMSR-E flying with other instruments aboard Aqua in 2002 will provide key data on cloud formation, precipitation, water vapor, air temperature and radiative properties. AMSR-E was contributed by the National Space Development Agency (NASDA) of Japan, and HSB was contributed by the Brazilian National Institute for Space Studies (INPE).



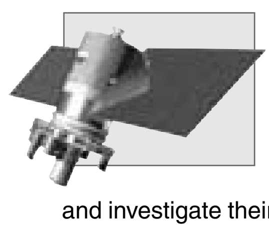
Aura Mission

HIRDLS, MLS, OMI and TES flying aboard Aura in 2003 will measure ozone, aerosols, and other key atmospheric constituents that play an important role in air quality and climate. The data will assist in the evaluation of environmental policies and international agreements on the chlorofluorocarbon (CFC) phase out. HIRDLS is a joint effort of the University of Colorado and Oxford University, and OMI was contributed by the Netherlands and Finland.



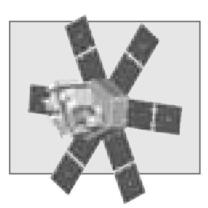
GOES Missions

The NOAA Geostationary Operational Environmental Satellites (GOES) circle the Earth in a geosynchronous orbit 35,800 kilometers (approximately 22,100 miles) above the Earth, at a speed matching the Earth's rotation. This allows them to hover continuously over one position on the Earth's surface providing a constant vigil for the atmospheric triggers of severe weather events such as tornadoes, flash floods, hailstorms, and hurricanes.



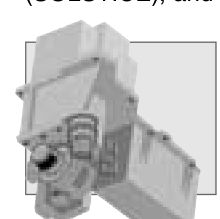
METEOR 3M Mission

SAGE III, flying aboard Russia's METEOR 3M satellite, will characterize upper tropospheric and stratospheric aerosols, clouds, ozone and selected trace gases, and investigate their effects on the Earth's environment.



SORCE Mission

The SOlar Radiation and Climate Experiment (SORCE) consists of a small, free-flying satellite carrying four instruments to measure solar radiation incident at the top of the Earth's atmosphere. It is scheduled for launch in late 2002 carrying the Total Irradiance Monitor (TIM), Spectral Irradiance Monitor (SIM), Solar Stellar Irradiance Comparison Experiment (SOLSTICE), and the XUV Photometer System (XPS).



TOMS

Since November, 1978, data from the Total Ozone Mapping Spectrometer (TOMS) have enabled the detection and monitoring of the change to the ozone layer over several parts of the globe. This led to curtailing the production of ozone-depleting chemicals through an international treaty signed in Montreal in the 1980s.

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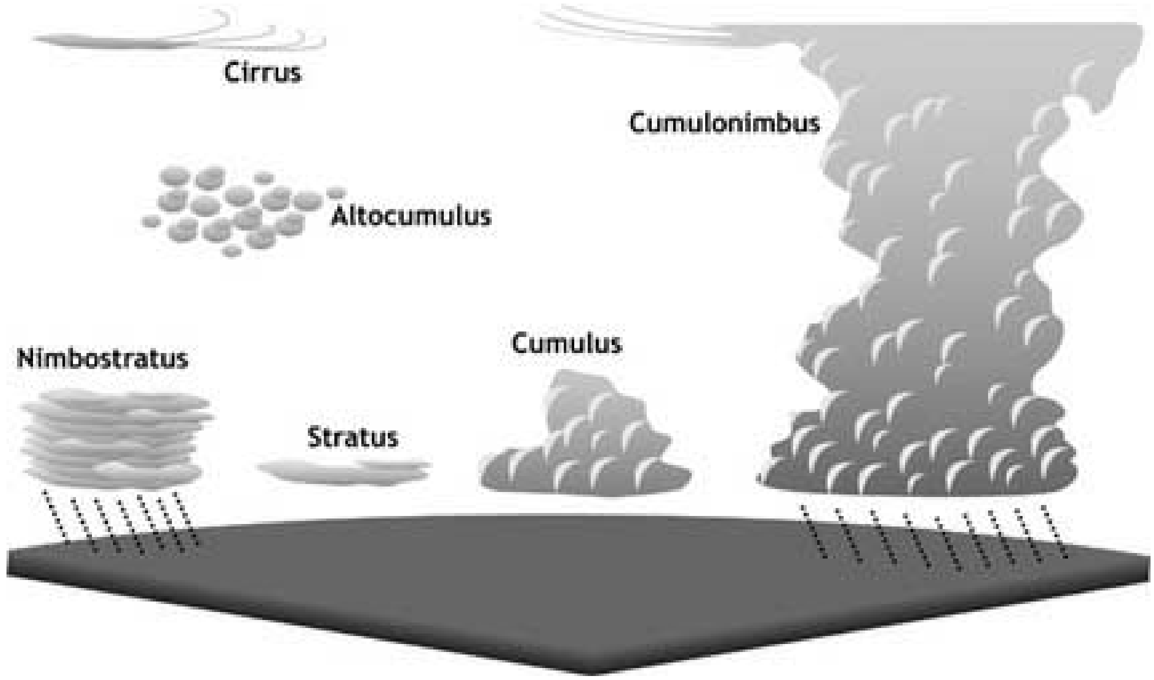
Cloud Types — Examples



What types of clouds have you seen in the sky? They come in three types:

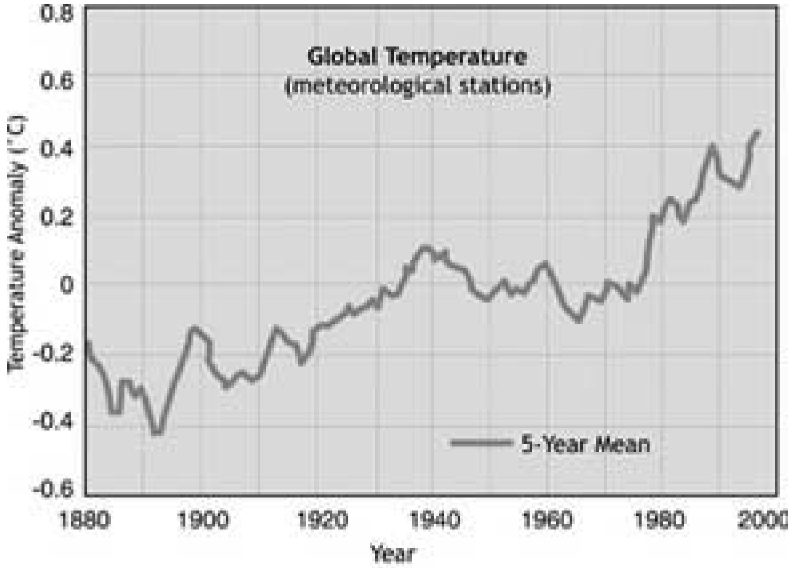
1. High clouds consisting of cirrus, cirrostratus and cirrocumulus;
2. middle clouds consisting of altostratus and altocumulus; and
3. low clouds consisting of cumulus, stratocumulus, nimbostratus and cumulonimbus

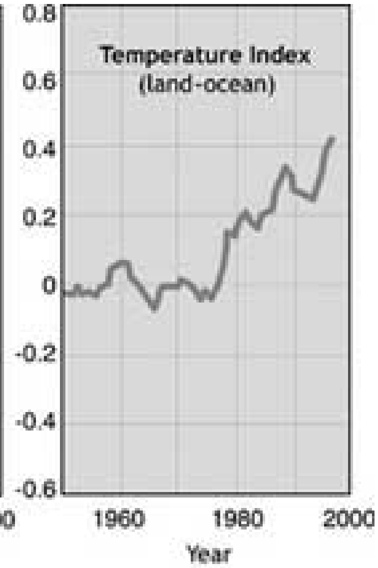
High clouds are composed mainly of ice crystals and often look like curled delicate white streaks in the sky, a thin transparent white sheet, or a layer of small white puffs or ripples. Middle clouds are usually made of liquid water droplets (sometimes ice crystals) and can create a uniform white or gray sheet over the sky, as well as form white or gray puffs or waves of clouds in patches or layers. Low clouds are made of liquid water droplets (in cold weather may contain ice and snow) and can form patches or layers of large rolls, or merged puffs, or they can create a uniform gray layer over the sky that sometimes produces rain. Some clouds with low bases have a significant vertical development, e.g., nimbostratus and cumulonimbus.

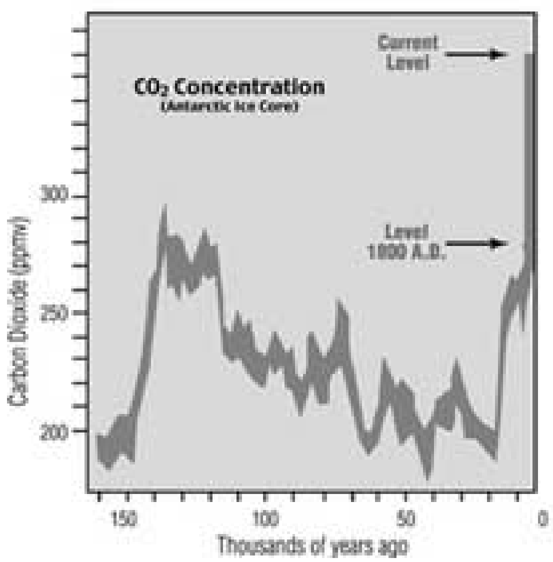
Cumuliform clouds have a heaped or puffy appearance and develop vertically. Clouds that look like detached heaps or puffs with sharp outlines and flat bases, and slight or moderate vertical extent are called cumulus clouds. These are composed of water droplets. On the other hand, clouds that are large and puffy in appearance with great vertical development are usually cumulonimbus clouds. They have smooth or flattened tops shaped like an anvil and are usually associated with heavy precipitation, lightning, and thunder. They contain liquid water droplets at the base and ice particles at the top, and can reach higher than 18.2 kilometers (11.3 miles).

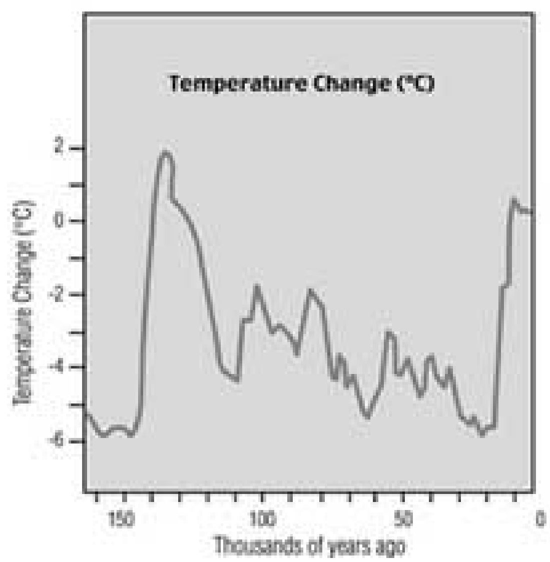
The study of clouds, how they form, and their characteristics, may well be a central key to understanding climate change. Low thick clouds primarily reflect solar radiation and cool the surface of the Earth. High, thin clouds primarily transmit incoming solar radiation; at the same time, they trap some of the outgoing infrared radiation emitted by the Earth and radiate it back downward, thereby warming the surface of the Earth.

Global Temperatures









According to researchers at the NASA Goddard Institute for Space Studies, who analyze data collected from several thousand meteorological stations around the world, there has been a long-term global warming trend underway since the early 1960s, with 1998 being the warmest year in the period of satellite instrumental data (see the Global Temperature chart above). The 1999 data show a continuation of that warming trend. The Temperature Index chart combines sea surface temperature measurements from satellites with land surface air temperature measurements from meteorological stations to produce a more truly global land-ocean temperature index than land stations alone could provide.

As demonstrated in the lower two charts, data from tiny air bubbles trapped in an Antarctic ice core show that atmospheric CO_2 concentrations and temperatures from 160,000 years ago to pre-industrial times are closely correlated. Recent measurements of CO_2 concentration and temperature extend this record to the present day, and confirm that CO_2 concentrations have risen to 360 parts per million by volume (ppmv) and temperatures have increased 0.6°C (1.1°F) over the last 100 years.

Data sources: Ice core data from Barnola, J.M. et al., Nature*, **329**, 408-414 (1987); current data from the Carbon Dioxide Information Analysis Center, 1997, Oak Ridge TN*

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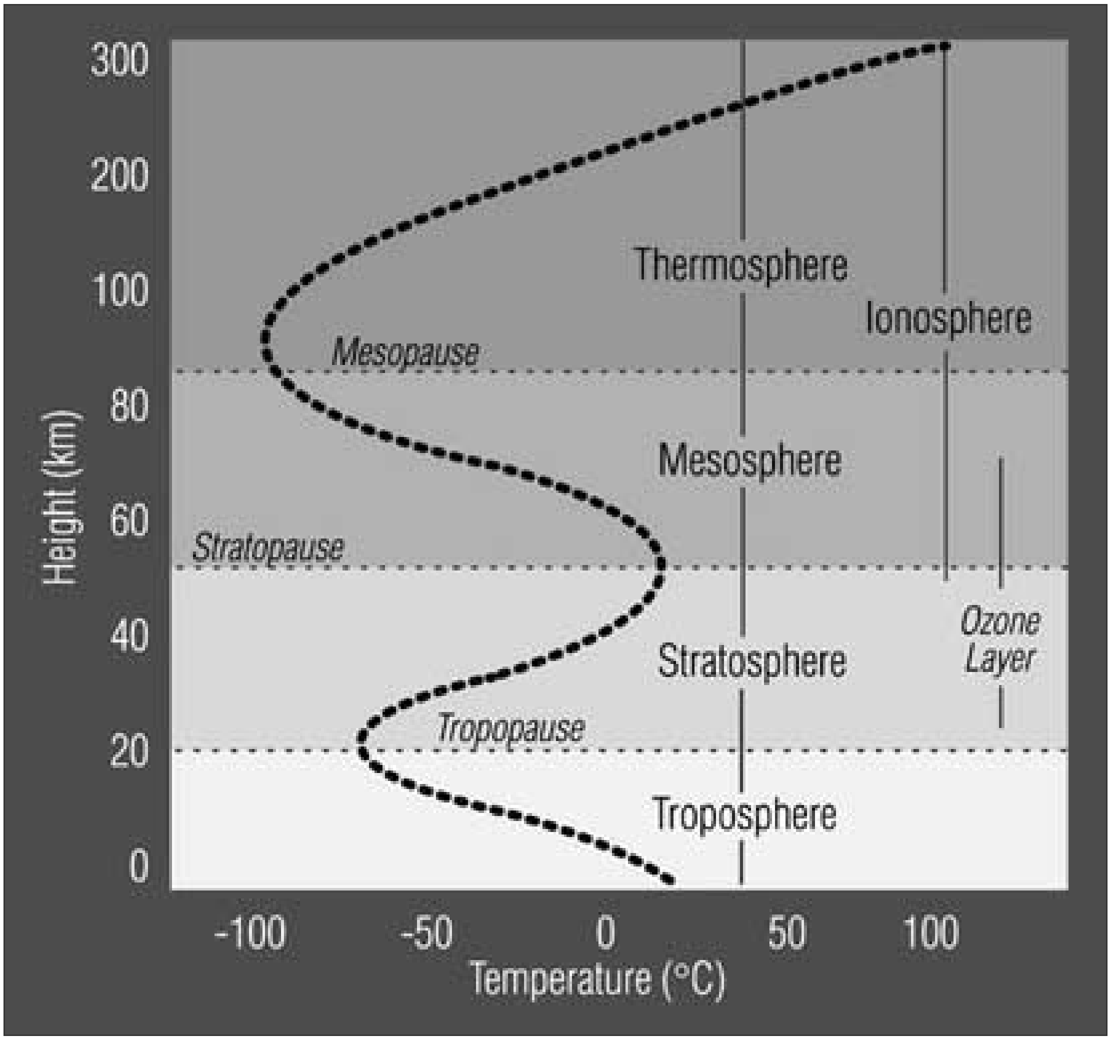
Layers of the Atmosphere



The troposphere is the lowest layer of the Earth's atmosphere, extending to a height of 8-15 kilometers (about 5-9 miles), depending on latitude. The stratosphere, warmer than the upper troposphere, is the next layer and rises to a height of about 50 kilometers (about 31 miles). Temperatures in the mesosphere, 50 to 80 kilometers (31 to 50 miles) above the Earth, decline with altitude to -70° to -140°C (-94° to -220°F), depending upon latitude and season. Temperatures increase again with altitude in the thermosphere, which begins about 80 kilometers (50 miles) above the Earth. They can rise to 2,000°C (about 3600°F). The exosphere begins at 500 to 1,000 kilometers (about 310-621 miles) and the few particles of gas there can reach 2,500°C (about 4500°F) during the day.

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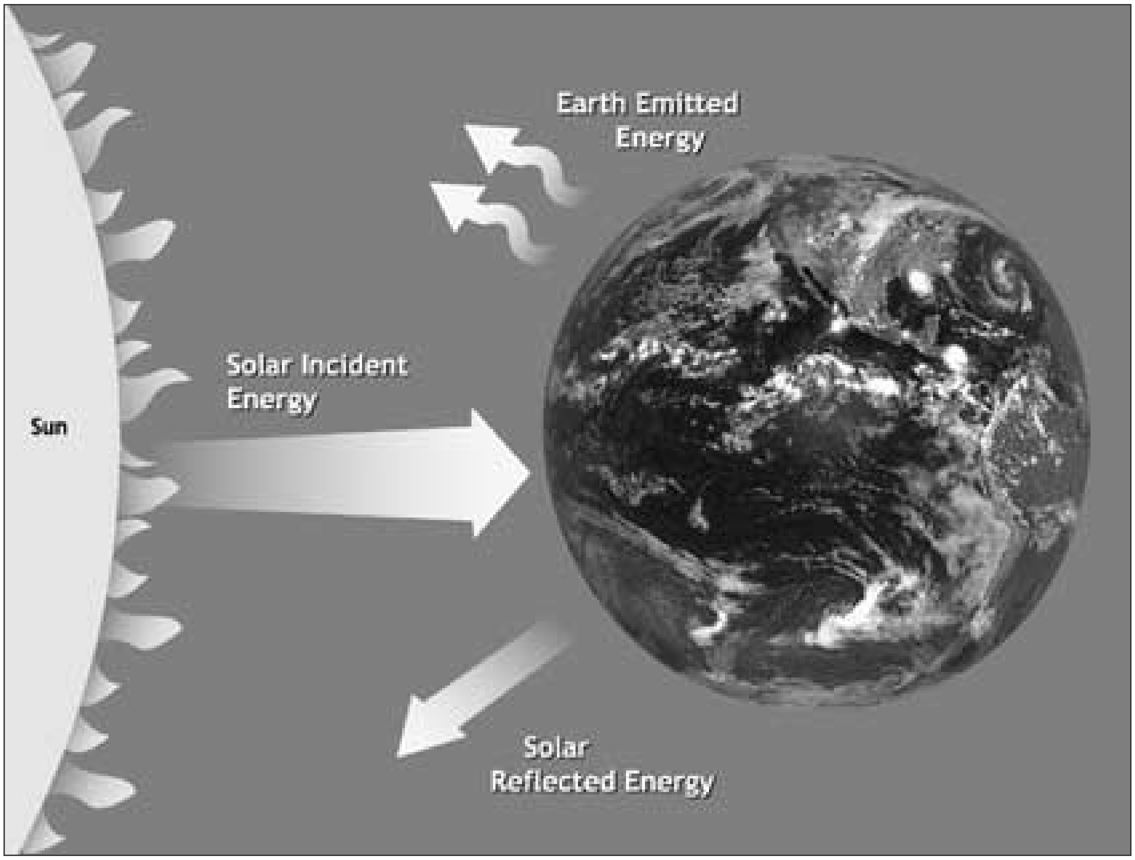
Earth's Radiation Components



The Earth's surface is kept warm through one source: the Sun. It is the primary source for Earth's energy. Some of the incoming sunlight and heat energy is reflected back into space by Earth's surface, gases in the atmosphere, and clouds; some of it is absorbed and stored as heat. When the surface and atmosphere warm, they emit heat, or thermal energy, into space. The "radiation budget" is an accounting of these energy flows. If the radiation budget is in balance, then Earth should be neither warming nor cooling, on average.

Clouds, atmospheric water vapor and aerosol particles play important roles in determining global climate through their absorption, reflection, and emission of solar and thermal energy.

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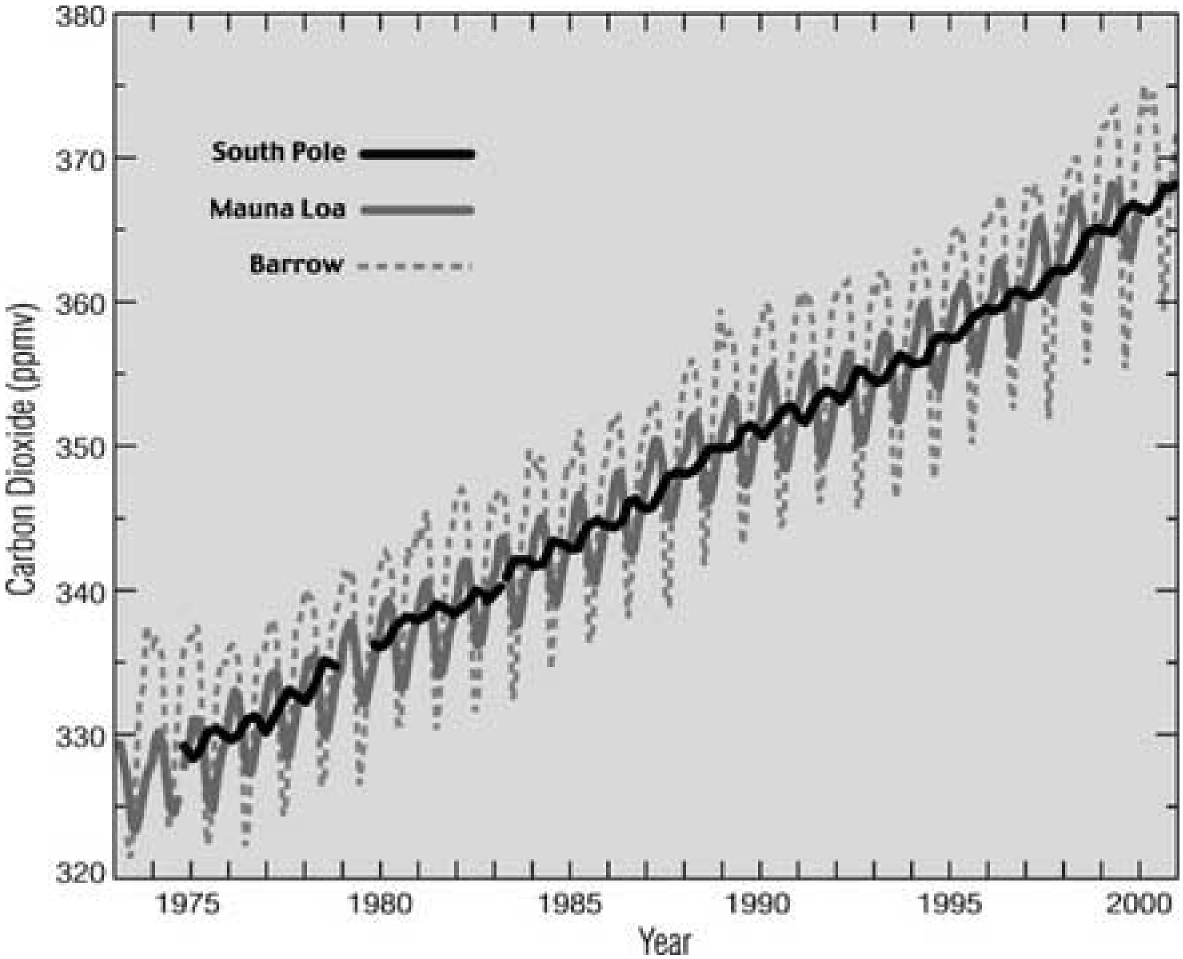
Carbon Dioxide Levels



This chart represents atmospheric carbon dioxide (CO_2) monthly mean mixing ratios determined from the continuous monitoring programs at three NOAA Climate Monitoring and Diagnostics Laboratory baseline observatories: the South Pole, Mauna Loa, Hawaii, and Barrow, Alaska. Atmospheric CO_2, a major greenhouse gas, has increased approximately 40 ppmv since 1958, largely because of human activities. The "zig-zag," up-and-down motion of the graph represents seasonal cycles due to photosynthetic activity (the processing of CO_2 by vegetation). The potential effect of the increase in atmospheric CO_2 levels, as well as other greenhouse gases such as methane, is a major focus of NASA's Earth Science Enterprise.

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For the Classroom...

Introduce major concepts of "Air—Our Atmosphere" by dividing the class into small teams to research several of the questions below. Students can research their answers using the poster and the Internet links found at the URL below. Students can prepare presentations to cooperatively instruct other teams using pre-established teacher criteria.

- Why is the study of our atmosphere important?
- Why is NASA involved in the study of atmospheric processes?
- What is haze and how does it affect incoming solar radiation in the atmosphere? What can cause haze?
- Make a list of the greenhouse gases. Why are they called greenhouse gases?
- How does each cloud type affect the radiation balance of the Earth?
- Explain the formation and destruction of stratospheric ozone and its effects on people.
- What effect can you have on our atmosphere?

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