NASA Facts

National Aeronautics
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Satellites – A Global View of Earth

Global environmental change is one of the most pressing international concerns of the 21st Century. These changes may include the effects of global warming, stratospheric ozone depletion, and large-scale changes in land cover due to human activities such as biomass burning.

In the 1960s, the desire to monitor the Earth's environment was linked with new technology that enabled us to observe our planet from space - giving humans our first global view of Earth.

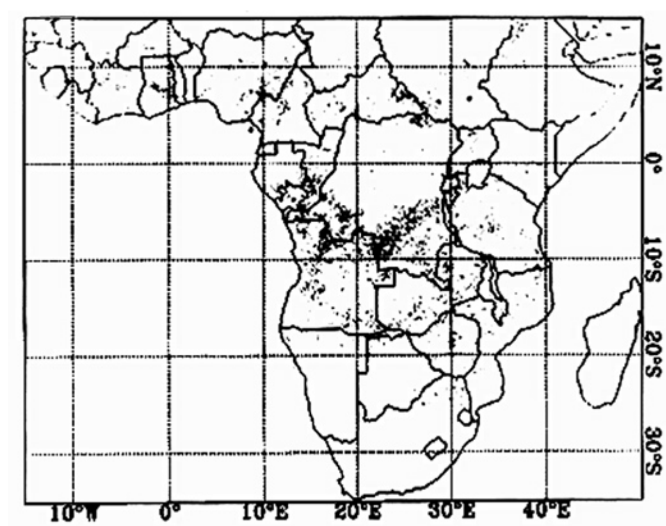
What are satellites?

Before 1957, the word satellite meant one thing — a small body that revolved around a larger astronomical body. Today we call these "natural satellites." In 1957, the Soviets launched the first "artificial satellite," Sputnik 1. Today there are hundreds of artificial satellites in orbit around the Earth. These satellites are used for many purposes, such as communications, weather forecasting, and navigation, as well as observing the Earth.

Satellites used to observe the Earth carry a variety of instruments to study the land, ocean, air and life, as well as their interactions. Scientists at NASA's Langley Research Center use several satellites now in orbit to measure some very specific atmospheric phenomena, such as the amount of ozone in the atmosphere, and to help them distinguish between environmental changes caused by humans and those that occur naturally.

Data gathering and interpretation

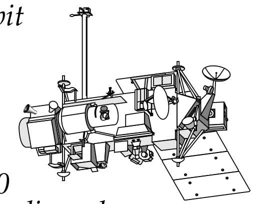
The technology used on a satellite varies, depending on its mission. Computers aboard a satellite can receive, store and transmit information in the form of radio signals sent to and from stations on Earth. For Earth



It was not until scientists made satellite measurements that they realized the true extent of global biomass burning. Biomass burning proved to be 100 times greater than was originally thought. The above annual data shows the number of fires which burned in Africa during 1995. Individual fires areas are shown as black dots.

scientists, the receipt of the data begins a long process of determining what the data means. By incorporating the data into computer models (which use mathematical formulas called algorithms) researchers can simulate, or model, Earth's processes — how the atmosphere, oceans and land surfaces interact as a system. Scientists hope that incorporating global satellite data into their computer models will help them better understand the interactive roles of Earth's systems, and help them predict how the Earth's environment will change over time.

Most satellites are lifted into orbit by multistage rockets. Satellites, powered by solar cells and auxiliary batteries, orbit more than 100 miles above the Earth's surface. The satellite's orbit, and the instruments it carries, are dependent on its mission. Communication satellites orbit more than 22,000 miles above the Earth relaying radio and TV signals, while most Earth-observing satellites orbit several hundred miles about the surface measuring the atmosphere, oceans and surface.



Some Ongoing NASA Satellite Missions

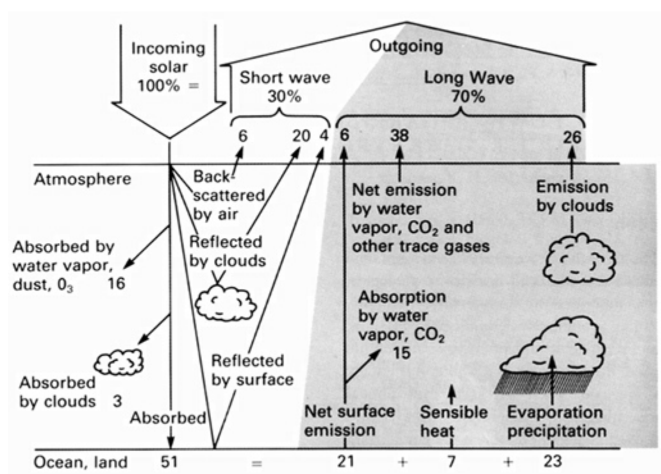
NASA Langley researchers use many satellites to study atmospheric variables and their effects

• MAPS •

THE **M**EASUREMENT OF **A**IR **P**OLLUTION FROM **S**ATELLITES (**MAPS**) instrument produced the first global measurements of atmospheric carbon monoxide (CO) in 1981 when it flew aboard the Space Shuttle Columbia (STS-2). MAPS' most important finding was that air pollution is a worldwide phenomenon, not just a problem in industrialized countries. In 1981, and in subsequent shuttle flights in October 1984 and 1994, MAPS measured high values of CO pollution in the tropics caused by seasonal biomass burning. In 1997, MAPS will be mounted to the Russian space station Mir to monitor global CO levels during a year of seasonal changes.

• ERBE •

THE **E**ARTH **R**ADIATION **B**UDGET **E**XPERIMENT (**ERBE)** is made up of three satellites launched in the mid-1980s. Since then, ERBE has been the primary source of global data for studying the heating and cooling of the atmosphere. This data may tell us the extent to which global warming is occurring. ERBE technology also measures the effects of clouds on the exchange of energy between the sun, Earth and space. The ERBE sensors measure energy from the sun in various wavelengths: reflected shortwave solar radiation (light that does not reach the Earth but is reflected off clouds) and longwave emitted energy (the



Earth's energy budget: The exchange of energy between the sun, Earth, clouds and space. Numbers are percentages.

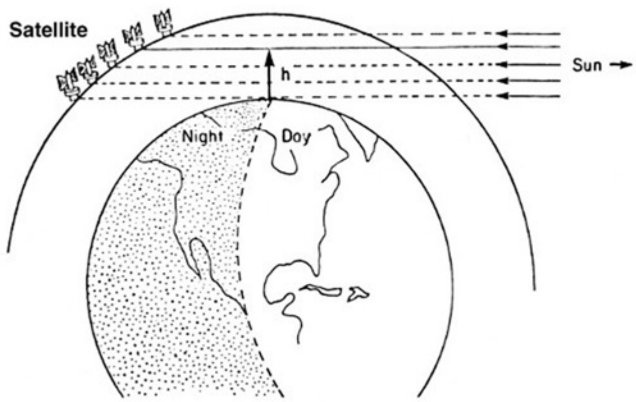


Diagram of the solar occultation technique

heat that is emitted into space by the Earth). By analyzing long-term measurements of these energy components, scientists can study the Earth's climate. ERBE has provided the most accurate data ever obtained on short- and longwave radiant energy, helping us better understand how clouds reflect and absorb sunlight, and the heat emitted by the Earth into space. NASA scientists have used this data to make important contributions to climate prediction by improving how clouds are represented in atmospheric models.

• CERES •

THE **C**LOUDS AND THE **E**ARTH'S **R**ADIANT **E**NERGY **S**YSTEM **(CERES)** instrument is a follow-on to ERBE. CERES will be able to better identify cloud properties as well as help scientists better understand the Earth's energy budget. CERES will be launched in late 1997 aboard the **T**ropical **R**ainfall **M**easuring **M**ission (TRMM) spacecraft, as part of NASA's Mission To Planet Earth Program.

• SAGE I AND II •

THE **S**TRATOSPHERIC **A**EROSOL AND **G**AS **E**XPERIMENT I **(SAGE I)** measured ozone, particles in the upper atmosphere (aerosols) and nitrogen dioxide from 1979 to 1981. Using a process called solar occultation, sensors on SAGE I measured sunlight coming through the atmosphere to determine how much sunlight was absorbed. The amount of absorption indicates the amount of various sunlight absorbing gases, like ozone, or aerosols, that are present. Solar occultation occurs as the satellite experiences sunrises and sunsets, when the light is not too bright to obscure readings. SAGE I produced the first global atmospheric data of this type.

SAGE II began operation in 1984 with the launch of the Earth Radiation Budget Satellite. SAGE II, which is still operating, provides global measurements of the vertical structure of ozone, nitrogen dioxide, water vapor and stratospheric aerosols. The SAGE II data helped scientists understand the causes and effects of the Antarctic ozone hole, and has made invaluable contributions to understanding the decline of stratospheric ozone over the Earth's mid-latitudes.

• HALOE •

THE **H**ALOGEN **O**CCULTATION **E**XPERIMENT **(HALOE)**, launched in 1991 aboard the Upper Atmosphere Research Satellite (UARS), measures ozone and other atmospheric gases. Like SAGE I and II, HALOE uses the solar occultation technique; however, it measures visible infrared light and uses a filter which separates the gases according to their individual light "signatures." Analysis of the HALOE data proved conclusively that the Antarctic ozone hole was caused by human-produced chlorofluorocarbons (CFCs).

Conclusion

The adage, "a picture is worth a thousand words," holds especially true for satellite data - a global satellite "picture" can help scientists "see" the whole Earth and better understand its many

Causes and Effects of Global Change

Global Warming

Global warming occurs, in part, because of the increase of certain atmospheric gases, such as carbon dioxide and methane, often caused by human activities. These gases trap heat inside the Earth's atmosphere. Increases in global temperatures over time could change precipitation patterns and growing seasons in many parts of the world. While isolated data sets gathered from several locations on Earth indicated global warming was occurring, it was not until satellite data found a worldwide change that scientists began to see the correlation between the factors contributing to this warming, the rate at which it might occur, and the role of human activities.

Ozone Depletion

Ozone is a gas in the upper atmosphere (stratosphere) that absorbs harmful ultraviolet radiation from the sun, protecting life on Earth. Ozone depletion occurs when ozone reacts with chlorine and other compounds in the presence of sunlight. NASA satellite studies have found that the main source of chlorine in the stratosphere is human-produced chlorofluorocarbons (CFCs) which are used in refrigeration, air conditioners, and industrial solvents and cleaners. When CFCs are released, they drift up into the stratosphere and can destroy ozone. The destruction of ozone has been documented through satellite observations since the 1980s. Because of this evidence, nations throughout the world signed the 1987 Montreal Protocol to phase out production and use of CFCs by the year 2000.

Deforestation

Human impacts on the Earth's system are most visible in changes to the land. As human population grows, we alter the landscape for agriculture, to harvest timber, and to build citiess. Deforestation and changes to land cover reduce the Earth's ability to absorb carbon dioxide, a major greenhouse gas. Land cover change also influences local weather and climate, and reduces biodiversity. Through satellite studies, NASA scientists study global vegetation and other land processes to better understand their role in regulating the Earth's climate.

Global Biomass Burning

Biomass burning is the burning of the world's living and dead vegetation for land clearing, land use change and domestic use. Approximately 90 percent of global burning is human initiated; a small percent is the result of lightning. Biomass burning has increased considerably over the last century. Biomass burning is a significant global source of carbon dioxide and methane, the leading greenhouse gases. Burning also produces gases which lead to the production of ozone in the lower atmosphere where it is harmful to living things. Smoke from the burning produces methyl bromide which leads to the depletion of ozone in the stratosphere, and the carbon particles become atmospheric aerosols which can block sunlight..

Natural Changes

Not every change is human-made. Although relatively small in comparison to human factors, natural occurrences also play a role in global change. For example, volcanic eruptions, such as the 1991 eruption of Mount Pinatubo in the Philippines, can inject large quantities of dust, gases and particles (aerosols) into the atmosphere that produce short-term effects similar to climate change. Aerosols from the eruption of Mount Pinatubo cooled global temperatures through 1993. Because eruptions are natural variations in the climate record, studying volcanoes provides valuable information to global climate change researchers.

interdependent systems. NASA will continue to study the Earth from space, and improve our satellite remote sensing abilities, through its ongoing Mission to Planet Earth Program.

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