NASA Facts

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Clouds and the Earth's Radiant Energy System (CERES)

EOS-Terra: Understanding Earth's Clouds and Climate

The Clouds and the Earth's Radiant Energy System (CERES) instrument is one of several that will be flown aboard the Earth Observing System's Terra spacecraft, scheduled for launch in late1999. The data from the CERES instrument will be used to study the energy exchanged between the Sun; the Earth's atmosphere, surface and clouds; and outer space.

The CERES EOS-Terra instrument will be the second CERES instrument in Earth orbit. The first CERES instrument is currently orbiting the Earth aboard the Tropical Rainfall Measuring Mission observatory, which was launched in November 1997. Early results of the TRMM mission show that the first CERES has provided better measurement capabilities than any previous satellite instrument of its kind.

What CERES Will Measure

CERES will measure the energy at the top of the atmosphere, as well as estimate energy levels in the atmosphere and at the Earth's surface. Using information from very high resolution cloud imaging instruments on the same spacecraft, CERES also will determine cloud properties, including cloud amount, altitude, thickness, and the size of the cloud particles. All of these measurements are critical for advancing our understanding of the Earth's total climate system and further improving climate prediction models.

The CERES instrument is based on NASA Langley's highly successful Earth Radiation Budget Experiment (ERBE) which used three satellites to provide global energy budget measurements from 1984 to 1990.

Balancing the Earth's Energy Budget

The Earth's daily weather and climate (long-term weather patterns) are controlled by the balance between the amount of solar energy received by the Earth (by both its surface, and its atmosphere and clouds) and the amount of energy emitted by the Earth into space. Scientists have been working for decades to understand this critical energy balance - to understand the budget of incoming and outgoing energy, called the Earth's "energy budget."

The energy received from the Sun is at short wavelengths while the energy emitted by the surface of the Earth and by clouds is at long wavelengths. Increases in the amounts of greenhouse gases (gases in the atmosphere that absorb the long wavelength energy emitted by the Earth) can lead to a warming of the Earth's surface. Such changes may, in turn, cause changes in the Earth's daily weather and climate.

Some of the shortwave radiation from the Sun is also reflected back into space by clouds and small particles in the atmosphere called aerosols. Major sources of aerosols include windblown dust, emissions from the burning of fossil fuels such as gasoline, and the burning of forests and agricultural fields ("biomass burning").

Cloud Effects

One of the most intriguing questions facing climate modelers today is how clouds affect the Earth's climate and vice versa. The U.S. Global Change Research Program classifies understanding the role of clouds and the Earth's energy budget as its highest scientific priority. Understanding cloud effects requires a detailed knowledge of how clouds absorb and reflect incoming shortwave solar energy, as well as how they absorb and re-emit outgoing longwave energy. For example, low, thick clouds primarily reflect incoming solar energy back to space causing cooling. Thin, high clouds, however, primarily trap outgoing longwave energy and produce warming. To date, satellite studies have found that clouds have an overall net cooling effect on the Earth.

Analyses of satellite data have also shown that clouds which form over water are very different from clouds which form over land. These differences affect the way clouds reflect sunlight back into space and how much longwave energy from the Earth the clouds absorb and re-emit. For example, over the equatorial Pacific Ocean during El Niño events, there is a significant decrease in the amount of energy emitted by the Earth due to increased cloudiness. El Niño events occur when portions of the eastern Pacific Ocean become considerably warmer than normal, causing an increase in cloudiness over the region. These changes can affect weather patterns around the world.

Water Vapor Effects

Water vapor in the atmosphere also affects our daily weather and climate, though scientists are only beginning to understand how this complex mechanism works. Water vapor acts like a greenhouse gas, absorbing outgoing longwave energy. Because water vapor also condenses to make clouds, an increase in water vapor in the atmosphere also may increase the amount of clouds.

Future Missions

Three more CERES instruments will be flown following the EOS-Terra launch. These include the EOS-Aqua satellite in 2000. Follow-up CERES missions will be used to create a continuous 15-year history of highly accurate energy budget and cloud data for enhanced climate analyses. All six CERES instruments were built by the TRW Space & Electronics Group in Redondo Beach, Calif.

Educational Outreach Programs

As a CERES instrument passes overhead, students world-wide are making cloud observations, then sending their observations to the NASA Langley Distributed Active Archive Center where the data is stored for further analysis by the CERES science team. The observations are part of a global educational outreach program called the Students' Cloud Observations On-Line (S'COOL) project.

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