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The Earth Radiation Budget Experiment (ERBE):

Using Satellites to Better Understand the Earth's Climate

The Earth Radiation Budget Experiment (ERBE) is designed around three Earth-orbiting satellites: the NASA Earth Radiation Budget Satellite (ERBS), and two NOAA satellites. The data from these satellites is being used to study the energy exchanged between the Sun, the Earth and space. The ERBE instrument aboard ERBS, launched from the Space Shuttle Challenger in October 1984 (STS-41G), had the primary goals of determining, for at least one year: the Earth's average monthly energy budget and its monthly variations, the seasonal movement of energy from the tropics to the poles, and the average daily variation in the energy budget on a regional scale (data every 160 miles). All of these first year goals were met, and the ERBE instrument continues to provide valuable data.

ERBE has helped scientists world-wide better understand how clouds and aerosols, as well as some chemical compounds in the atmosphere (so-called 'greenhouse' gases), affect the Earth's daily and long-term weather (the Earth's 'climate'). In addition, the ERBE data has helped scientists better understand something as simple as how the amount of energy emitted by the Earth varies from day to night. These diurnal changes are also very important aspects of our daily weather and climate.

Balancing the Earth's Radiation Budget

The Earth's daily weather and climate is controlled by the balance between the amount of sunlight received by the Earth (both its surface and atmosphere) and the amount of energy emitted by the Earth into space. Scientists have been trying for decades to understand this critical balance - to understand the budget of incoming and outgoing energy, called the radiation budget. Much like our own financial budgets of incoming and outgoing money, the Earth's climate works better when the energy budget is balanced.

The instruments aboard the ERBE satellites measure the amount of solar energy received by the Earth, the energy emitted by the Earth into space, and the amount of solar radiation which is reflected into space. The energy received from the sun is at short wavelengths while the energy emitted by the surface of the Earth and clouds is long wavelength radiation. Some of the short-wave radiation from the sun is reflected back into space by water vapor, ozone, clouds and small particles in the atmosphere called aerosols. Gases which absorb the longwave radiation emitted by the Earth (Fig. 1) are known as “greenhouse” gases. Increases in the amount of greenhouse gases can lead to a warming of the atmosphere, which can, in turn, cause changes in the Earth’s daily and long-term weather (‘climate’).

Clouds and Water Vapor Affect Climate

One of the most intriguing questions facing climate modelers today is how clouds affect the climate and vice versa. Understanding these effects requires a detailed knowledge of how clouds absorb and reflect both incoming shortwave solar energy and outgoing longwave Earth radiation. Analyses of the ERBE data have shown that clouds which form over water are very different than 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, ERBE has provided data for investigating the significant decrease in the Earth’s emitted radiation due to increased cloudiness over the equatorial Pacific Ocean during El Niño events, which occur when the ocean becomes considerably warmer than normal. The ERBE results are very important to scientists working to improve computer models for climate and weather prediction.

Water vapor in the atmosphere also affects our daily weather and climate, though scientists are only beginning to understand how these complex mechanisms work. 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 in the atmosphere. Using the ERBE data, scientists have begun to understand the effects of water vapor and how its variability affects clouds and ultimately, the energy balance of the Earth.

ERBE’s Future

During the past 10 years, ERBE data has been invaluable for scientists studying the energy interactions between the Sun, clouds and Earth, and the effects of these interactions on our weather and climate. ERBE satellite measurements have provided new information on Earth’s radiation at the top of the atmosphere including the important radiative effects of clouds on our climate.

Clouds and the Earth’s Radiant Energy System (CERES), based on the highly successful ERBE, is currently being developed. CERES will extend the important ERBE measurements to include the top of the atmosphere, in the atmosphere, and global surface radiation, which are critical for advancing our understanding of the Earth’s total climate system and improving climate prediction models. CERES will be flown on multiple satellites starting with a launch on the Tropical Rainfall Measuring Mission in 1997, followed by a launch on the Earth Observing System (EOS)-AM satellite in 1998 and the EOS-PM satellite in 2000.

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