If Earth were a movie screen, there would be no need for MISR. Movie screens are made of a material that reflects light nearly equally in all directions. So for people sitting in the right, left, and center sections of the theater, the movie looks equally sharp and bright.

But Earth is a more complicated place: its surface, the clouds, even tiny particles floating in the air, each reflect light differently when viewed at different angles. This matters to us because the light being reflected is sunlight, which carries the energy that heats our planet. The ways in which sunlight is scattered — by forests; deserts; snow- and ice-covered surfaces; cumulus, stratus, and cirrus clouds; smoke from forest fires; and soot and other by-products of industry — all affect Earth’s climate.

Most satellite instruments look only straight down or toward the edge of the planet. To fully understand Earth’s climate, and to determine how it may be changing, we need to know the amount of sunlight that is scattered in different directions under natural conditions. MISR is a new type of instrument that will view Earth with cameras pointed in nine different directions. As the instrument flies overhead, each piece of the planet’s surface below will be successively imaged by all nine cameras, in each of four color bands (blue, green, red, and near-infrared).

MISR will fly on the National Aeronautics and Space Administration’s (NASA’s) first Earth Observing System (EOS) satellite — EOS AM-1 — together with four other instruments designed to study Earth from space. Launch is planned for 1999. The Jet Propulsion Laboratory (JPL) of the California Institute of Technology built the MISR instrument for NASA. JPL, in collaboration with the MISR science team, is also building the software to convert raw MISR data into information that Earth science researchers can use.
MISR can distinguish different types of clouds, atmospheric particles, and surfaces. Over time, MISR will monitor trends in:

- The amount and types of aerosols (tiny particles floating in the air) — those formed by natural processes and by human activity.
- The amounts, types, and heights of clouds.
- The distribution of vegetation types and other land-surface cover.

Aerosols tend to cool the surface below them, because most aerosols are bright particles that reflect sunlight back to space, reducing the amount of sunlight that can be absorbed at the surface. The magnitude of this effect depends on the size and composition of the aerosols, and on the reflecting properties of the underlying surface. Aerosol cooling may partially offset the expected warming due to increases in the amount of atmospheric carbon dioxide from human activity. But key details about aerosol properties needed to calculate even their current impact on climate are not known. MISR data will make it possible to determine global aerosol amounts with unprecedented accuracy, and to estimate particle size and composition.

Because they are very common, clouds play a major role in controlling Earth’s climate. Clouds may warm or cool the Earth, depending on their thickness and how they reflect incoming solar energy.

Earth’s land surface is constantly changing. There are natural variations, such as the progression of seasons, as well as changes caused by human activities, such as deforestation and desertification in overgrazed regions. And because we care about climate, the amount and manner in which surfaces around the globe reflect sunlight matters to us too. MISR will characterize in detail the reflection properties of Earth’s surface. From these observations, we will be able to tell where and how the surface is changing, as well as what effect these changes are likely to have on Earth’s climate.

MISR images, and for “intercalibration” with other instruments. The terms “Albedo” and “BRDF” refer to ways that a surface reflects light.

Each of the MISR color bands corresponds to one labeled column. In the lower part of the figure, colored boxes indicate that the corresponding camera is used for the science objective to the right. For example, the “An” camera (which looks straight down) is needed to geolocate MISR images, and for “intercalibration” with other instruments. The terms “Albedo” and “BRDF” refer to ways that a surface reflects light.

Each of the MISR color bands corresponds to one of the labeled rows in the figure. On the right side, colored boxes indicate that the corresponding color band is needed for the science objective at the top. For example, the 672-nanometer (red) and 866-nanometer (near-infrared) bands are used to detect aerosols over the ocean, since the ocean surface is darkest in these bands, making bright aerosols easier to see.
MISR will orbit the Earth about 705 kilometers (438 miles) above the ground. During a period of seven minutes, a 360-kilometer (224-mile) wide swath of Earth will successively come into the view of each of the nine cameras, as the instrument flies by. It takes nine days to cover the globe. MISR can see objects on the surface of Earth as small as 550 meters (0.34 mile) long. The camera in this image is one of the MISR "A" cameras, which have the shortest telescopes, and when mounted on the instrument, will look nearly directly downward toward Earth. (JPL-28033Ac)

MISR will fly together with four other instruments on NASA’s EOS AM-1 satellite. Three of the instruments will measure quantities related to Earth’s energy budget, covering aspects of both reflected sunlight and satellite. Three of the instruments will measure quantities related to the Earth’s brightness in four color bands, at each of nine look angles spread out along the flight path in the forward and aft directions. The nine separate cameras within the instrument are arranged for compactness in the shape of a “V-9” engine. In the artist’s rendition showing a cutaway view of the MISR instrument, the nine cameras appear as yellow cylinders. In this orientation, MISR would look down toward Earth.

To improve the scientific value of the data, special attention has been paid to accurately measuring the instrument’s sensitivity to light, which may change during its lifetime. This high absolute and relative radiometric calibration accuracy is achieved using onboard reflecting surfaces that, when commanded to move into position, will reflect sunlight into the instrument, will look nearly directly down toward Earth. (JPL-28033Ac)

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The MISR instrument is the size of a steamer trunk, and weighs 149 kilograms (328 pounds). To meet its scientific objectives, MISR will measure Earth’s brightness in four color bands, at each of nine look angles spread out along the flight path in the forward and aft directions. The nine separate cameras within the instrument are arranged for compactness in the shape of a “V-9” engine. In the artist’s rendition showing a cutaway view of the MISR instrument, the nine cameras appear as yellow cylinders. In this orientation, MISR would look down toward Earth.

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Currently, satellite instruments provide our best hope of making, at a reasonable cost, the routine global observations of aerosol, cloud, and surface properties needed to assess their climatic effects. But satellite instruments must rely on remote sensing — the study of light collected at a distance from the Earth’s surface and lower atmosphere.

How will we know if we are interpreting the MISR measurements correctly? This is the goal of the MISR Validation Program.

One of the main tools in the Validation Program is an instrument called AirMISR, which was built largely of spare parts from the MISR instrument. AirMISR contains a single camera on a rotating mount so it can view Earth at multiple angles. It flies at a height of about 20 kilometers (over 65,000 feet), above the clouds that affect our weather, in the nose of a NASA high-altitude aircraft. To AirMISR, Earth looks much as it does from space. But unlike the satellite instrument, AirMISR can be cleaned and tested regularly in the laboratory. So, at times during the six-year MISR mission, AirMISR will fly under the path of its satellite sister, making measurements to check those from the satellite.

AirMISR was readied for flight in 1997. And since MISR is one of the first instruments designed to take multangle images of Earth from space, AirMISR data are helping us develop methods to interpret multangle observations even before the spacecraft version of MISR is launched.

Some of the most accurate measurements of atmospheric properties and surface characteristics can be made from the ground. Field measurements of sky brightness, aerosol properties, and ground reflectance are also part of the MISR Validation Program.
The MISR instrument, covered with its protective gold blanket, is seen here as it was being tested in a simulated space environment at JPL in December 1996. The instrument will look much like this when it is flying in space; Earth would be toward the top of the picture. The black cover for the camera view ports is open, and for this test, a device placed over the instrument (curved metal object with cables at the top center of the box) provides a target for the cameras to image. Control equipment for the test electronics appears on the table in the foreground. (P-28315Ac)