Fact Sheet

National Aeronautics and
Space Administration

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SAGE III: At the Edge of the Earth

Essential Observations for Understanding Climate Change

Human activities are changing the Earth and its atmosphere. Long-term records show a rise in the global average temperature over the past few decades. Other observations reveal changes in the composition of the Earth's atmosphere such as thinning of the stratospheric ozone layer and increases in the concentration of greenhouse gases. Scientists do not fully understand how these changes will affect climate. Therefore, highly accurate, long-term measurements are essential for gaining a better understanding of the processes that control climate change.

The Stratospheric Aerosol and Gas Experiment (SAGE III) is a fourth-generation satellite instrument designed to observe the long-term health of the upper atmosphere. Managed by NASA Langley Research Center, SAGE III is part of NASA's Earth Science Enterprise program of climate research. It launched aboard a Russian Meteor 3M spacecraft in December 2001 for a three-year mission, a collaboration between NASA and the Russian Aviation and Space Agency (RASA). It extends a long-term working relationship between the United States and Russia to understand Earth's environment.

The goal of SAGE III is to measure high-resolution vertical profiles of key components of the upper atmosphere—the most important being ozone, aerosols (suspended particles) and water vapor. These measurements will enhance our understanding of climate and how human activities influence it. This information will enable national and international leaders to make informed policy decisions on climate change.

Aerosols and volcanic eruptions

Aerosols have many natural and human-induced sources, such as smoke from forest fires, wind-blown dust, pollution or volcanic eruptions. When present in large concentrations, aerosols can reflect significant amounts of solar radiation back to space and cause cooling at the Earth's surface. Depending upon the chemical composition of aerosol particles, they can absorb radiation from the sun or emitted from the Earth, causing the atmosphere to warm. Aerosols can also strongly influence atmospheric chemical processes, including those that control ozone. Because the characteristics of aerosols can vary considerably, understanding how aerosols affect climate is one of the major challenges confronting atmospheric scientists.

The SAGE III instrument will measure the distribution of aerosols from the middle troposphere through the stratosphere. For example, the predecessor to SAGE III the SAGE II satellite instrument, launched in 1984, observed the dispersal of volcanic aerosols following the massive eruption of Mt. Pinatubo in 1991. These measurements were crucial in linking a decline in the globally averaged surface temperature in mid-1992 of about 1 degree Fahrenheit to the large aerosol concentrations from the volcanic eruption. Aerosols from Mt. Pinatubo also strongly influenced the observed ozone trend— an effect that would not have been detected without measurements like those from SAGE II. The data provided unique insight into the complex flow of air in the stratosphere that is needed to gain a better understanding of how the upper atmosphere will respond to climate change.

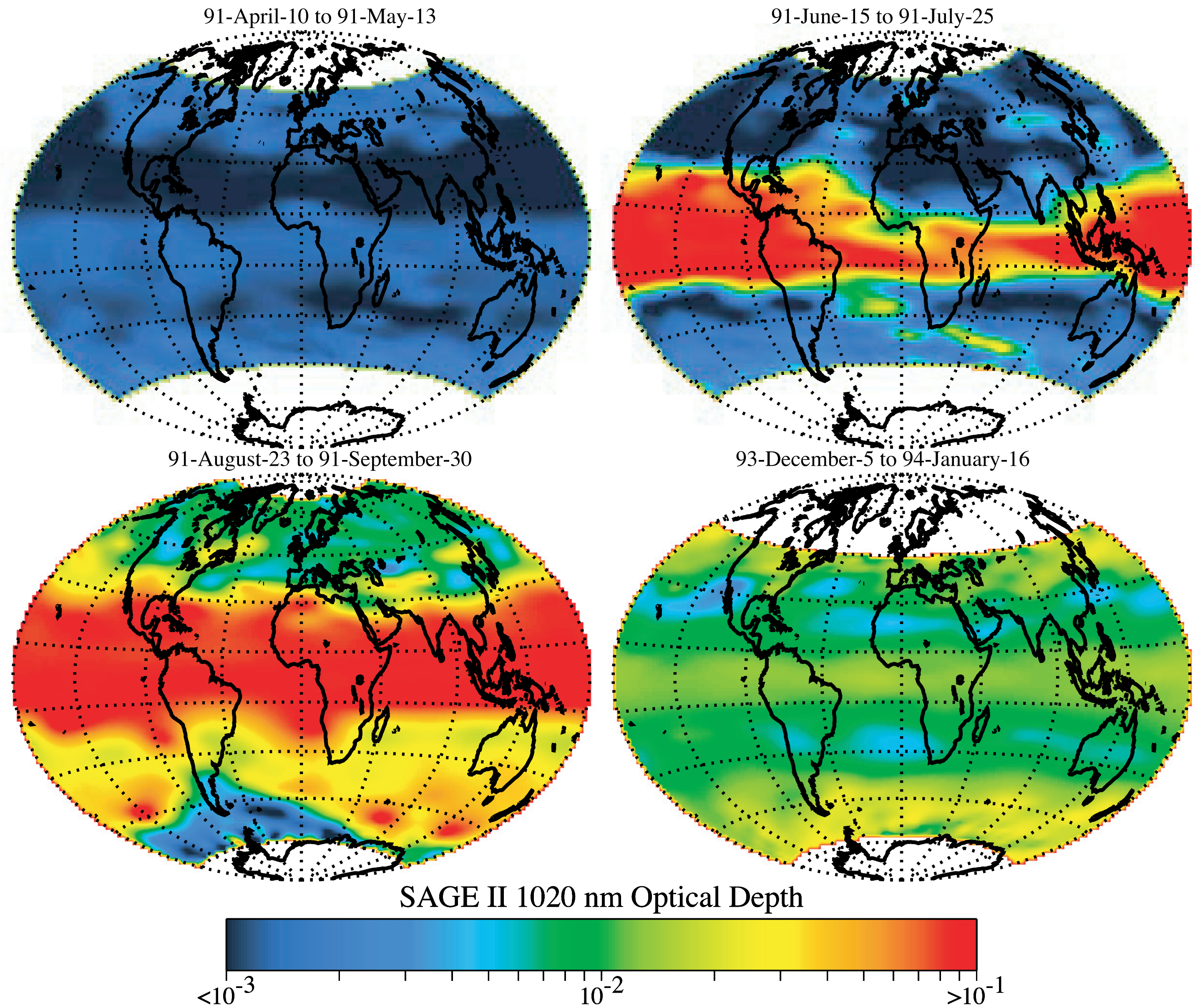
Ash plume from the eruption of Mt. Pinatubo in 1991.

Ozone in the upper atmosphere

In the stratosphere, ozone shields life at the surface from harmful solar ultraviolet radiation and plays an important role in controlling the circulation of air in the upper atmosphere. Changes in ozone distribution, like the ozone hole that forms in the spring over Antarctica, are also a concern to health officials because of the possibility for increased cases of melanoma and other skin cancers, cataracts and immune deficiencies in humans. Scientists now realize that ozone is being destroyed over the Arctic during late winter and more slowly over middle latitudes. A primary objective of the SAGE III instrument is to make accurate, long-term measurements of the concentration of stratospheric ozone and other chemical species that control the distribution of ozone.

Water vapor observations

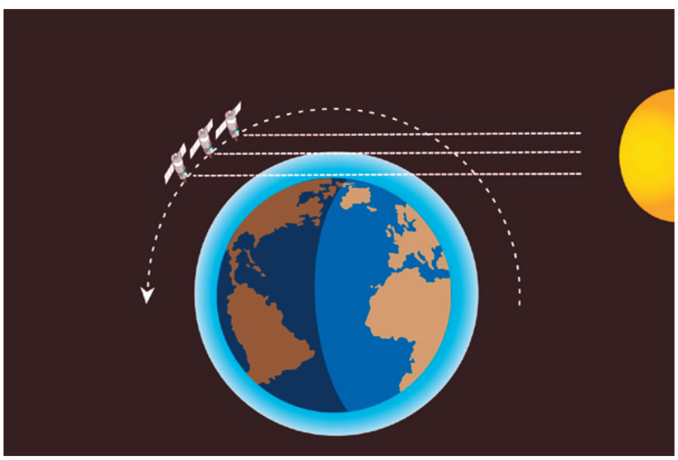
Atmospheric water vapor plays an important part in the Earth's energy balance, in many chemical cycles and in tracing the exchange of air between the upper and lower atmosphere. Water vapor is the most abundant, naturally occurring greenhouse gas and traps outgoing energy in the atmosphere that is radiated from the Earth. Precise measurements of water vapor by SAGE III will provide important contributions to understanding how this process warms the Earth's atmosphere. Evidence also indicates that water vapor in the upper atmosphere is increasing. This increase is not well understood, but it could affect climate, alter circulation patterns and allow ozone loss in the Arctic to occur more easily. Measurements by SAGE III will provide a crucial new understanding of how water vapor is circulated in the atmosphere and how it is increasing with time.



SAGE II observed the long-term global effects of the June 1991 eruption of the Mt. Pinatubo volcano in the Philippines. The eruption produced large quantities of aerosols in the upper atmosphere. The top-left graphic from SAGE II data shows a relatively aerosol-free atmosphere before the eruption. The top-right graphic reveals that aerosols in the tropics increased by almost a factor of 100 immediately following the eruption. The bottom-left graphic shows that aerosols had spread into the Earth's midlatitudes three months later. The bottom-right graphic illustrates how volcanic aerosols slowly decreased in the atmosphere over several years. The effects of Mt. Pinatubo lingered for up to 10 years following the eruption. The global distribution of aerosols as shown in these images is one of the many important stratospheric processes that SAGE III will monitor.

Making measurements at the edge of the Earth

The SAGE III instrument operates by measuring the amount of solar light as it passes through the limb or 'edge' of the Earth's atmosphere as the spacecraft views the rising and setting of the sun during each orbit. The instrument measures light at wavelengths in part of the electromagnetic spectrum visible to the human eye, allowing it to make very accurate measurements of aerosols, ozone, water vapor and other trace gases. The advanced SAGE III instrument will also make measurements using moonlight that will provide new observations of trace gas species that affect ozone distribution. SAGE III will also make essential temperature and pressure measurements for helping scientists better understand climate change.



A limb measurement is taken as a satellite instrument views sunlight through the atmosphere as it ascends or descends from behind the Earth.

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