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National Aeronautics and
Space Administration

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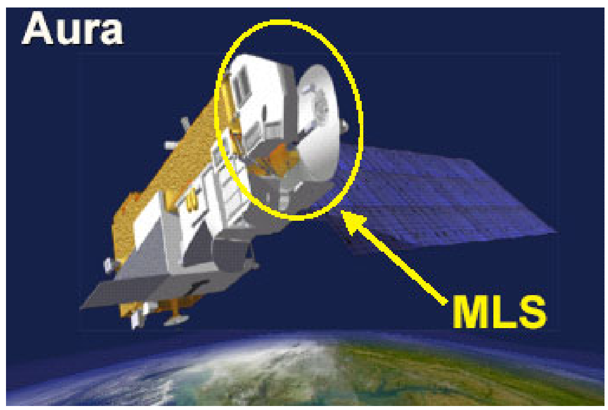
Earth Observing System Microwave Limb Sounder



The Earth Observing System Microwave Limb Sounder (MLS) instrument on NASA's Aura spacecraft is a passive radiometer/spectrometer that observes the natural thermal radiation emitted from Earth's limb (the edge of Earth's atmosphere) at spectral wavelengths ranging from 0.12 to 2.5 millimeters. From these data, measurements of atmospheric composition, temperature, cloud ice and pressure can be derived for various heights in Earth's troposphere (the lowest layer of the atmosphere, extending from the ground to about 15 kilometers, or 10 miles, in altitude) and stratosphere (extending from about 15 to 50 kilometers, or 10 to 30 miles, in altitude). Specific chemical species to be measured include water vapor, ozone, chlorine monoxide, bromine monoxide, hydrogen chloride, hydroxyl radical, hydroperoxy radical, nitric acid, hydrogen cyanide, nitrous oxide, carbon monoxide, hypochlorous acid and methyl cyanide.

MLS on Aura is a second-generation follow-on experiment to the highly successful MLS instrument on NASA's Upper Atmosphere Research Satellite (UARS), launched in 1991. It incorporates new technologies that will enable many more measurements than were previously possible, with greater precision and over a larger range of altitudes. The result will be the most complete monitoring of stratospheric chemistry to date, including the critical balances that maintain Earth's protective ozone layer. Particularly noteworthy in this regard are MLS on Aura's capabilities for measuring the hydroxyl radical, hydroperoxy radical and bromine monoxide, since continuous and global measurements of these species have not been previously made in the stratosphere.

MLS is one of four instruments aboard NASA's Aura spacecraft. In combination with the Tropospheric Emission Spectrometer (TES), Ozone Monitoring Instrument (OMI) and High-Resolution Dynamics Limb Sounder (HIRDLS), this instrument suite represents the most advanced and accurate atmospheric chemistry laboratory ever deployed in space. The Aura instruments will operate collectively to provide very comprehensive information on our atmosphere, yielding much more valuable data together than if they were operated separately.

MLS on Aura's primary science objectives are to:

1. Better understand the causes of ozone changes during the period when the ozone layer may begin to recover;
2. Understand aspects of how atmospheric composition affects climate variability; and
3. Quantify aspects of pollution in the upper troposphere.

MLS on Aura helps answer each of Aura's three main science questions. In addition, its objectives address three priority science areas of the U.S. Global Change Research Program:

1. Changes in ozone, ultraviolet radiation and atmospheric chemistry;
2. Decade-to-century climate change; and
3. Seasonal-to-interannual climate variability.

Monitoring Recovery of the Ozone Layer

MLS on Aura's measurements will be made at a time when ozone-destroying chlorine in the stratosphere should be near its peak abundance and beginning to slowly decline, following the worldwide ban on chlorofluorocarbons imposed by the Montreal Protocol. Together with Aura's High Resolution Dynamics Limb Sounder instrument, MLS on Aura will enable scientists to track the expected recovery of the ozone layer. It will do this by monitoring levels of many chemical species involved in the destruction of stratospheric ozone in the atmosphere, including chlorine monoxide and hydrogen chloride. It will also take the first-ever global measurements of the stratospheric hydroxyl and hydroperoxy radicals that are part of the hydrogen catalytic cycle that leads to ozone destruction. In addition, MLS on Aura will measure bromine monoxide, a powerful ozone-destroying radical that has both natural and human-caused sources. The MLS on Aura measurements will help scientists understand possible delays in ozone recovery caused by interactions between chemistry and changes in Earth's climate. Its measurements will help us better understand global stratospheric chemistry and will help explain observed trends in ozone, while also providing a very sensitive early warning of unexpected changes in stratospheric chemistry.

MLS on Aura's measurements of chlorine monoxide and hydrogen chloride will be especially important in studying Earth's polar regions. The hydrogen chloride measurements tell scientists how stable reservoirs of chlorine are converted to the ozone-destroying radical, chlorine monoxide. The measurements will help diagnose the potential for severe Arctic ozone loss. This is of particular interest to scientists, since the Arctic stratosphere may now be at a threshold for more severe ozone loss, should the stratosphere cool slightly while stratospheric chlorine levels remain relatively high.

Understanding the Link Between Atmospheric Composition and Climate Variability

Understanding the distribution of water vapor in the upper troposphere (8 to 15 kilometers, or 5 to 10 miles high) is essential to understanding climate variability and global warming. Until now, such measurements have been difficult to observe reliably on a global scale. MLS on Aura is unique in its ability to provide these measurements in the presence of tropical cirrus clouds, where important processes affecting climate variability occur. MLS on Aura also provides unique measurements of cirrus ice content. The simultaneous measurements of upper tropospheric water vapor, ice content and temperature will improve our understanding of processes that affect the distribution of atmospheric water, climate variability, and exchanges between the troposphere and stratosphere. The data will be used to refine models that attempt to stimulate these atmospheric processes.

MLS on Aura also measures greenhouse gases such as ozone and nitrous oxide in the upper troposphere. The simultaneous measurements of carbon monoxide and nitrous oxide enhance the value of these data by helping identify the source of the air masses being observed. Water at these heights influences how greenhouse gas and sea surface temperature variations affect climate. Little is known about how upper tropospheric water is controlled, nor do we know the details about how water enters the stratosphere, where it affects ozone-layer chemistry.

Quantify Pollution in the Upper Troposphere

Another key objective of MLS on Aura will be to measure certain pollutants in the upper troposphere (ozone, carbon monoxide, hydrogen cyanide and methyl cyanide). Carbon monoxide is an important trace gas that can indicate the exchange of air between the stratosphere and troposphere. It is also a precursor to the formation of tropospheric ozone and its appearance in the upper troposphere can indicate strong vertical transport from pollution events in the lower atmosphere. The MLS on Aura measurements will provide information on how regional pollution affects the global atmosphere. They will also be important for understanding the atmospheric effects of aviation and for diagnosing atmospheric exchanges between the troposphere and stratosphere.

Monitoring the Effects of Volcanic Plumes

MLS on Aura will measure sulfur dioxide and other gases in volcanic plumes, and investigate the effects of large volcanic injections into the atmosphere on ozone depletion and climate change.

The MLS Instrument

MLS on Aura is a passive microwave limb-sounding radiometer/spectrometer that looks “forward” from Aura, measuring a slice of the atmosphere every 1.5 degrees along the orbit path. It makes passive measurements in broad bands at five frequencies: 118 gigahertz (2.4 millimeters wavelength) for temperature and pressure; 190 gigahertz (1.6 millimeters wavelength) primarily for water and nitric acid; 240 gigahertz (1.3 millimeters wavelength) primarily for ozone and carbon monoxide; 640 gigahertz (0.47 millimeters wavelength) primarily for hydrogen chloride, chlorine monoxide, nitrous oxide, bromine monoxide, hydroperoxy radical and hypochlorous acid; and 2.5 terahertz (0.12 millimeters wavelength) for hydroxyl. Spatial resolution varies. The instrument works around the clock, making global measurements that are reliable even in the presence of ice clouds and volcanic aerosols that degrade other measurement techniques.

MLS on Aura contains sensitive “radio receivers” that “listen to” natural microwave signals emitted by trace amounts of key chemicals in Earth’s atmosphere. It can detect signals down to a millionth of a millionth of a millionth of a watt. This is possible due to advances in planar device technology invented by the Submillimeter Wave Advanced Technology Group and Micro-Devices Laboratory at NASA’s Jet Propulsion Laboratory, Pasadena, Calif. The new, more reliable planar diode devices replace awkward “whisker-contacted” diodes (the type used in early crystal radios). For example, at the 2.5 terahertz frequency, the diode anode measures just 0.2 by 1.0 microns, 10,000 times smaller than the cross-sectional area of a human hair. MLS on Aura also pioneers the use of monolithic-millimeter wave integrated circuits that make it more reliable and resilient to launch vibration.

MLS on Aura has a mass of 450 kilograms (992 pounds), consumes 550 watts of power, and has a data rate of 100 kilobits per second. Thermal control, in environments ranging from 10 to 35 degrees Celsius (50 to 95 degrees Fahrenheit), is maintained by radiators, louvers and internal heaters.

JPL developed, built, tested and will operate MLS on Aura. MLS teams at JPL and the University of Edinburgh, United Kingdom, are responsible for developing data product algorithms, monitoring instrument performance, processing instrument data, and performing data validation and analyses.

For more information about the Aura mission, see: http://eos-aura.gsfc.nasa.gov . For more information about MLS, see: http://mls.jpl.nasa.gov .

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