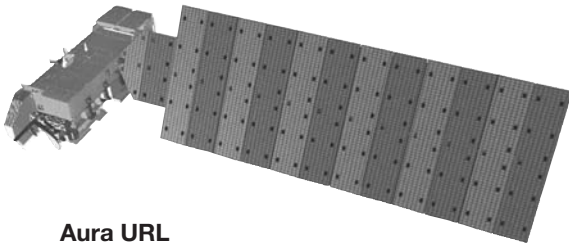


Aura



Aura URL
eos-aura.gsfc.nasa.gov/

Summary

Aura's four instruments study the atmosphere's chemistry and dynamics. Aura's measurements enable us to investigate questions about ozone trends, air-quality changes and their linkage to climate change. Aura's measurements also provide accurate data for predictive models and useful information for local and national agency decision-support systems.

Instruments

- High Resolution Dynamics Limb Sounder (HIRDLS)
- Microwave Limb Sounder (MLS)
- Ozone Monitoring Instrument (OMI)
- Tropospheric Emission Spectrometer (TES)

Points of Contact

- *Aura Project Scientist:* Mark Schoeberl, NASA Goddard Space Flight Center
- *Aura Deputy Project Scientist:* Anne Douglass, NASA Goddard Space Flight Center
- *Aura Deputy Project Scientist:* Joanna Joiner, NASA Goddard Space Flight Center

Other Key Personnel

- *Aura Program Scientist:* Phil DeCola, NASA Headquarters
- *Aura Program Executive:* Lou Schuster, NASA Headquarters
- *Aura Mission Director:* William Guit, NASA Goddard Space Flight Center

Mission Type

Earth Observing System (EOS) Systematic Measurements

Key Aura Facts

Joint with the Netherlands, Finland, and the U.K.

Orbit:

- Type: Polar, sun-synchronous
- Equatorial Crossing: 1:45 p.m.
- Altitude: 705 km
- Inclination: 98.2°
- Period: 100 minutes
- Repeat Cycle: 16 days

Dimensions: 4.70 m × 17.37 m × 6.91 m

Mass: 2967 kg (1200 kg of which are in instruments)

Power: Solar array provides 4800 W. Nickel-hydrogen battery for nighttime operations.

Downlink: X-band for science data; S-band for command and telemetry via Tracking and Data Relay Satellite System (TDRSS) and Deep Space Network to polar ground stations in Alaska and Norway.

Design Life: Nominal mission lifetime of 5 years, with a goal of 6 years of operation.

Contributor: Northrop Grumman Space Technology

Launch

- *Date and Location:* July 15, 2004, from Vandenberg Air Force Base, California
- *Vehicle:* Delta II 7920 rocket

Relevant Science Focus Areas

(see NASA's Earth Science Program section)

- Atmospheric Composition
- Climate Variability and Change
- Weather

Related Applications

(see Applied Sciences Program section)

- Agricultural Efficiency
- Air Quality
- Public Health

Aura Science Goals

The Aura mission seeks to answer three main science questions:

- Is the stratospheric ozone layer recovering?
- What are the processes controlling air quality?
- How is Earth's climate changing?

Aura Mission Background

Aura is the third in the series of large Earth Observing System platforms to be flown by NASA with international contributions. Aura, along with Terra (launched December 1999) and Aqua (launched May 2002), provides an unprecedented view of the global Earth system. The Aura mission consists of four instruments on a common spacecraft (the same bus design as for Aqua) designed to provide the essential services for the instruments.

Aura is part of the A-Train of satellites, which, when the formation is complete, will include at least four other NASA missions—Aqua, Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO), CloudSat, and the Orbiting Carbon Observatory (OCO)—as well as a French Centre National d'Etudes Spatiales (CNES) mission called Polarization and Anisotropy of Reflectances for Atmospheric Sciences coupled with Observations from a Lidar (PARASOL). Aura is the trailing spacecraft in the formation and lags 15 minutes behind Aqua. While each satellite has an independent science mission, measurements from the various spacecraft can also be combined. These complementary satellite observations will enable scientists to obtain more information than they could if all the various observations were used independently. This offers a new and unprecedented resource for exploring aerosol-chemistry-cloud interactions. See the Earth Observing Program section for more details on the A-Train.

As suggested in part by the name, the objective of the Aura mission is to study the chemistry and dynamics of Earth's atmosphere, with emphasis on the upper troposphere and lower stratosphere (5–20 km altitudes). Aura's measurements enable us to investigate questions about ozone trends and air-quality changes, and their linkages to climate change. They also provide accurate data for predictive models and provide useful information for local and national agency decision-support systems.

Aura Mission Validation

Aura's focus on the troposphere and lower stratosphere presents challenges for validation, because this region exhibits much more spatial and temporal variability than the middle and upper stratosphere. To meet these challenges, the Aura project has adopted a strategy to increase the scientific return from the validation program. Some of the validation activities are embedded within focused science campaigns. These campaigns have been selected to obtain data needed to unravel complex science questions that are linked to the three main Aura science goals. Scientists plan to use the satellite data to understand the overall chemical and meteorological environment during the campaigns. Aircraft measurements are used both to

validate Aura data and to address the science by making additional measurements.

This strategy emphasizes the strengths of both focused science campaigns and aircraft measurements. Campaign instruments make constituent measurements that are more complete than can be obtained from satellites. Campaign data are also obtained for much smaller spatial scales and with high temporal resolution compared to satellite data. Aircraft missions, on the other hand, take place a few times each year at most and are limited to a small portion of the globe. The Aura instruments make global observations throughout the year and provide data sets that reveal whether or not the campaign observations are truly representative of the atmosphere's chemistry.

The Aura validation program also capitalizes on routine sources of data such as the ozonesonde network and the Network for the Detection of Atmospheric Composition Change (formerly the Network for Detection of Stratospheric Change, or NDSC). Ground-based radiometers and spectrometers make column measurements similar to those made by instruments flying on Aura. Ground-based lidars measure temperature and some trace-gas constituent profiles. Balloon-borne instruments measure profiles of stratospheric constituents up to 40 km. Smaller balloons carry water-vapor instruments in the tropics to validate Aura's measurements of this important gas. Flights of aircraft, such as the DC-8 (medium altitude) and WB-57 (high altitude), provide tropospheric profiles of ozone, carbon monoxide, and nitrogen species. Aircraft lidars measure profiles of ozone and temperature for long distances along the satellite track. Scientists can also compare profiles of stratospheric constituents from Aura with those from other satellites, including the NASA Upper Atmosphere Research Satellite (UARS), the European Space Agency Environmental Satellite (ESA Envisat), and the Canadian Science Satellite (SCISAT) and use data-assimilation techniques to help identify systematic differences among the data sets. The Aura validation program also includes an instrument development program and field campaigns scheduled between October 2004 and Autumn 2007.

Aura Science Questions

Is the Stratospheric Ozone Layer Recovering?

Ozone is formed naturally in the stratosphere through break-up of oxygen (O_2) molecules by solar UV radiation, followed by the uniting of individual oxygen atoms with O_2 molecules, forming ozone (O_3) molecules. Ozone is destroyed when an ozone molecule combines with an oxygen atom to form two oxygen molecules, or through catalytic cycles involving hydrogen, nitrogen, chlorine, or bromine-containing species. For centuries, the atmo-

sphere has maintained a delicate natural balance between ozone formation and destruction.

In recent years, however, man-made chemicals, such as chlorofluorocarbons (CFCs), have altered the natural balance of ozone chemistry. International agreements, such as the Montreal Protocol and its amendments, have been enacted to control these ozone-destroying chemicals, and recent data show that ozone is being depleted at a slower rate than a decade ago. However, it is too soon to tell if this trend is a result of the international protocols restricting CFC production or whether other factors explain the reduction in the rate of ozone loss.

Information returned from Aura's four instruments helps us answer these questions about ozone. The instruments measure the total ozone column, ozone profiles, and gases important in ozone chemistry. They also measure important sources, radicals, and reservoir gases that play active roles in ozone chemistry. The data gathered help to improve our ability to predict ozone changes and also help us better understand how transport and chemistry impact ozone trends.

What are the Processes Controlling Air Quality?

Agricultural and industrial activity have grown dramatically along with the human population. Consequently, in parts of the world, increased emissions of pollutants have significantly degraded air quality. Respiratory problems and even premature deaths due to air pollution occur in urban and some rural areas of both industrialized and developing countries. Widespread burning for agricultural purposes (biomass burning) and forest fires also contribute to poor air quality, particularly in the tropics. The list of culprits contributing to the degradation of air quality includes tropospheric ozone, a toxic gas, and other chemicals whose presence, accompanied by the right atmospheric conditions, leads to the formation of ozone. These so-called ozone precursors include oxides of nitrogen (NO_x), carbon monoxide (CO), methane (CH_4), and other hydrocarbons. Human activities such as biomass burning, inefficient coal combustion, other industrial activities, and vehicular traffic all produce ozone precursors.

The U.S. Environmental Protection Agency (EPA) has identified six pollutants: carbon monoxide, nitrogen dioxide, sulfur dioxide, ozone, lead, and particulates (aerosols). Of these six pollutants, ozone has proven the most difficult to control. Ozone chemistry is complex, making it difficult to quantify the contributions to poor local air quality. Pollutant-emission inventories needed for predicting air quality are uncertain by as much as 50%. Also uncertain is the amount of ozone that enters the troposphere from the stratosphere.

For local governments struggling to meet national air-quality standards, knowing more about the sources and transport of air pollutants has become an important issue. Most pollution sources are local, but satellite observations show that winds can carry pollutants great distances, for example from the western and mid-western states to the east coast of the United States and sometimes even from one continent to another. We have yet to quantify accurately the extent of inter-regional and inter-continental pollution transport.

Aura Instruments

HIRDLS

High Resolution Dynamics Limb Sounder

HIRDLS is an advanced 21-channel infrared radiometer measuring the 6–17- μm thermal emission of Earth's limb designed to provide critical information on atmospheric chemistry and climate. It provides accurate measurements of trace gases, temperature, and aerosols in the upper troposphere, stratosphere, and mesosphere, with daily global coverage at high vertical resolution.

MLS

Microwave Limb Sounder

MLS is an advanced microwave radiometer that measures microwave emission from the Earth's limb in five broad spectral bands. MLS measures trace gases at lower altitudes and with better precision and accuracy than its predecessor on UARS. MLS can provide reliable measurements even in the presence of cirrus clouds and dense volcanic aerosols.

OMI

Ozone Monitoring Instrument

OMI is a nadir-viewing wide-field imaging spectroradiometer that serves as Aura's primary instrument for tracking global ozone change and continues the high quality column-ozone record begun in 1970 by the Nimbus-4 BUV. OMI measures backscattered ultraviolet and visible radiation and provides daily global coverage of most of Earth's atmosphere. Data returned permit modeling of air pollution on urban-to-super-regional scales.

TES

Tropospheric Emission Spectrometer

TES is a high-spectral-resolution infrared-imaging Fourier-transform spectrometer that generates three-dimensional profiles on a global scale of most infrared-active species from Earth's surface to the lower stratosphere.

The Aura instruments are designed to study tropospheric chemistry. Together these instruments provide global monitoring of air pollution on a daily basis and measure five out of the six criteria pollutants identified by the Environmental Protection Agency. Aura provides data of suitable accuracy to improve industrial emission inventories and also helps distinguish between industrial and natural sources. Information provided by Aura may lead to improvements in the accuracy of air-quality forecast models.

How is Earth's Climate Changing?

Carbon dioxide and other gases trap infrared radiation that would otherwise escape to space. This phenomenon, called the greenhouse effect, contributes to making the Earth habitable. Increased atmospheric emissions of trace gases that trap infrared radiation from industrial and agricultural activities are causing climate change. Quantities of many of these gases in the atmosphere have increased and this has added to the greenhouse effect. During the 20th century, the global mean lower tropospheric temperature increased by more than 0.4° C. This increase is thought to be greater than during any other century in the last 1000 years.

Improved knowledge of the sources, sinks, and the distribution of greenhouse gases is needed for accurate predictions of climate change. Aura measures greenhouse gases such as methane, water vapor, and ozone in the troposphere and lower stratosphere. Aura also measures both absorbing and reflecting aerosols in the lower stratosphere and lower troposphere, measures upper tropospheric water-vapor and cloud-ice concentrations, and makes high-vertical-resolution measurements of some greenhouse gases in a broad swath (down to the clouds) across the tropical upwelling region. All of these measurements contribute key data for climate modeling and prediction.

Instrument Descriptions

Each of Aura's four instruments makes important contributions to answering the three science questions described above. The goal with Aura is to achieve 'synergy'—meaning that more information about the condition of the Earth is obtained from the combined observations of the four instruments than would be possible from the sum of the observations taken independently. The four instruments were carefully designed to achieve the overall mission objectives. Each has different fields of view and complementary capabilities.

HIRDLS

High Resolution Dynamics Limb Sounder

HIRDLS Background

HIRDLS is an advanced 21-channel infrared radiometer observing the 6–17 μm thermal emission of the Earth's limb and designed to provide critical information on atmospheric chemistry and climate. It provides



accurate measurements of trace gases, temperature, and aerosols in the upper troposphere, the stratosphere, and the mesosphere, with daily near-global coverage at high vertical resolution. HIRDLS looks backward and to the side away from the Sun and scans vertically. Very precise gyroscopes provide instrument-pointing information for HIRDLS. To detect the weak infrared radiation from the Earth's limb, HIRDLS detectors must be kept at temperatures below liquid nitrogen. An advanced cryogenic refrigerator is used to keep the detectors cool.

The University of Colorado, Oxford University (U.K.), the National Center for Atmospheric Research (NCAR), and Rutherford Appleton Laboratory (U.K.) designed the HIRDLS instrument. Lockheed Martin built and integrated the instrument subsystems. The National Environmental Research Council funded the U.K.'s participation.

HIRDLS Contributions to Science Questions

Is the Stratospheric Ozone Level Recovering?

The largest ozone depletions occur over the poles in the lower stratosphere during winter. Therefore, HIRDLS makes concentrated measurements in the northern polar region and retrieves high-vertical-resolution daytime and nighttime ozone profiles over the poles.

HIRDLS also measures NO_2 , HNO_3 , and CFCs, all gases that play a role in stratospheric ozone depletion. Although international agreements have banned their production, CFCs are long-lived and will remain in the stratosphere for several more decades. By measuring profiles of the long-lived gases, from the upper troposphere into the stratosphere, HIRDLS can assess the transport of air from the troposphere into the stratosphere.

What are the Processes Controlling Air Quality?

HIRDLS measures ozone, nitric acid, and water vapor in the upper troposphere and lower stratosphere. With these measurements, scientists can estimate the amount of stratospheric air that descends into the troposphere and this allows scientists to better distinguish between natural ozone sources and pollution originating from man-made sources. This is an important step forward in quantifying the level at which human activities are impacting the air we breathe.

How is Earth's Climate Changing?

HIRDLS measures water vapor and ozone. Accurate measurement of greenhouse gases such as these are important because scientists input this information into models they use to predict climate change. The more accurate the information that goes into these models, the more accurate and useful the resulting predictions will be. HIRDLS is also able to distinguish between aerosol types that absorb or reflect incoming solar radiation and can map high thin cirrus clouds that reflect solar radiation. This new information allows scientists to better understand how to represent aerosols and thin cirrus clouds in climate models.

HIRDLS Principal Investigators

John Barnett, Oxford University (U.K.)

John Gille, University of Colorado and NCAR (U.S.)

HIRDLS URLs

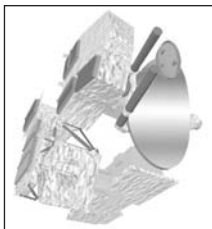
www.eos.ucar.edu/hirdls/
www.atm.ox.ac.uk/hirdls/

MLS

Microwave Limb Sounder

MLS Background

MLS is an advanced microwave radiometer that measures microwave emission from the Earth's limb in five broad spectral bands. These bands are centered at 118 (dual polarization), 190, 240, 640 GHz, and 2.5 THz (dual polarization). MLS can measure trace gases at lower altitudes and with better precision and accuracy than its predecessor on UARS. In addition, MLS obtains trace-gas profiles with a typical vertical resolution of 3 km and has a unique ability to measure trace gases in the presence of ice clouds and volcanic aerosols. MLS pioneers the use of planar diodes and monolithic millimeter-wave integrated circuits to make the instrument more reliable and resilient to launch vibration. MLS looks outward from



Key HIRDLS Facts

Heritage: Limb Radiance Inversion Radiometer (LRIR); Limb Infrared Monitor of the Stratosphere (LIMS) and Stratospheric and Mesospheric Sounder (SAMS); Improved Stratospheric and Mesospheric Sounder (ISAMS), and Cryogenic Limb Array Etalon Spectrometer (CLAES)

Instrument Type: Limb viewing vertical scanning radiometer*

Spectral Range: 6–17 μm , using 21 channels

Scan Type: Vertical limb scans at fixed position*

Scan Range: Elevation, 22.1° to 27.3° below horizontal, +43° on anti-sun side

Dimensions: 149.9 cm \times 118.5 cm \times 130.2 cm

Detector IFOV: 1.25 km vertical \times 10 km horizontal

Duty Cycle: 100%

Power: 262 W (average), 365 W (peak)

Data Rate: 70 kbps

Thermal Control: Detector cooler, Stirling-cycle, heaters, surface coatings, radiator panel

Contributors

Instrument Design: University of Colorado, Oxford University (U.K.), National Center for Atmospheric Research (NCAR), and Rutherford Appleton Laboratory (U.K.)

Instrument Assembly and Integration: Lockheed Martin built and integrated instruments

Funding: National Environmental Research Council (U.K.)

* HIRDLS was originally designed to scan vertically at seven different horizontal positions across the satellite track. Unfortunately, the horizontal scanning capability was lost during launch and the instrument now can only scan vertically at a fixed position.

the front of the spacecraft and obtains vertical scans of the limb. NASA's Jet Propulsion Laboratory (JPL) developed, built, tested, and operates MLS.

MLS Contributions to Science Questions

Is the Stratospheric Ozone Layer Recovering?

MLS continues the ClO and HCl measurements made by UARS. These measurements provide important information on the rate at which stratospheric chlorine is destroying ozone and the total chlorine loading of the stratosphere. MLS provides the first global measurements of the stratospheric hydroxyl (OH) and hydroperoxy (HO₂) radicals that are part of the hydrogen catalytic cycle for ozone destruction. In addition, MLS measures bromine monoxide (BrO), a powerful ozone-destroying radical with both manmade and naturally occurring sources.

MLS measurements of ClO and HCl are especially important in the polar winters. Taken together, these measurements help scientists determine what fraction of stable chlorine reservoirs (HCl) is converted to the ozone-destroying radicals (ClO). Since recent research results indicate that the Arctic stratosphere may now be at a threshold for more severe ozone loss due to climate change, the MLS data are of critical importance for understanding observed changes in Arctic winter ozone.

What are the Processes Controlling Air Quality?

MLS measures carbon monoxide (CO) and ozone in the upper troposphere. CO is normally created in the lower troposphere by incomplete burning of hydrocarbons and is an ozone precursor. When scientists observe heightened concentrations of CO and ozone at the higher levels of the troposphere, it is an indicator of strong vertical transport in the troposphere. These observations can serve as a useful tool for tracking the movement of polluted air masses in the atmosphere.

How is Earth's Climate Changing?

MLS makes measurements of upper tropospheric and lower stratospheric water vapor, ice content, and temperature. Accurate measurements of all of these constituents are needed to help scientists create models that can predict how the Earth's climate is likely to change in the future. MLS also measures ozone and nitrous oxide (N₂O)—both important greenhouse gases—in the upper troposphere and lower stratosphere.

MLS Principal Investigator

Nathaniel Livesey, NASA Jet Propulsion Laboratory/California Institute of Technology

MLS URL

mls.jpl.nasa.gov/

Key MLS Facts

Heritage: Microwave Limb Sounder (MLS)

Instrument Type: Microwave radiometer

Scan Type: Vertical limb scan in plane of orbit, done by moving reflector antenna

Calibration: Views 'blackbody' target and 'cold' space with each limb scan

Spectral Bands: Broad bands centered near 118, 190, 240, and 640 GHz and 2.5 THz

Spatial Resolution: Measurements are performed along the suborbital track, and resolution varies for different parameters; 5-km cross-track × ~200-km along-track × 3-km vertical are typical values

Dimensions: 150 cm × 190 cm × 180 cm (GHz sensor); 80 cm × 100 cm × 110 cm (THz sensor); 160 cm × 50 cm × 30 cm (spectrometer)

Mass: 455 kg

Duty Cycle: 100%

Power: 544 W full-on

Data Rate: 100 kbps

Thermal Control: Via radiators and louvers to space as well as heaters

Thermal Operating Range: 10–35° C

FOV: Boresight 60–70° relative to nadir, in plane of orbit

Instantaneous FOV at 640 GHz: 1.5 km vertical × 3 km cross-track × 200 km along-track at the limb tangent point

Pointing Requirements (platform+instrument, 3σ):

Control: 36 arcsec

Knowledge: 1 arcsec per s

Stability: 72 arcsec per 30 s

Jitter: 2.7 arcsec per 1/6 s

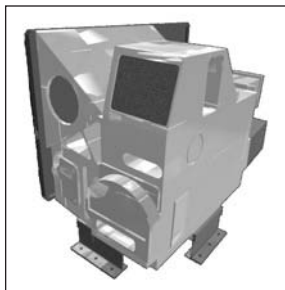
Contributor: NASA JPL developed, built, tested, and operated MLS; U.K. University of Edinburgh contributed to data processing algorithms and validation.

OMI

Ozone Monitoring Instrument

OMI Background

OMI is an advanced hyperspectral imaging spectrometer with a 114° field of view. Its nadir spatial resolution ranges from 13 km × 24 km to 13 km × 48 km for ozone profiles. It has a 2600-km viewing swath that runs perpendicular to the orbit track so that OMI's swaths almost touch at the equator, enabling complete coverage of the sunlit portion of the atmosphere each day. OMI contains two spectrometers: one measures the UV in the wavelength range of 270–380 nm, while the other measures the visible in the range of 350–500 nm. Both spectrometers have a bandpass of about 0.5 nm with spectral sampling over the range 0.15–0.32 nm/pixel, depending on wavelength. OMI uses a charge-coupled device (CCD) solid-state detector array to provide extended spectral coverage for each pixel across the measurement swath.



OMI is Aura's primary instrument for tracking global ozone change and continues the high-quality column-ozone record begun in 1970 by the Nimbus-4 BUV. Because OMI has a broader wavelength range and better spectral resolution than previous instruments, i.e., OMI's horizontal resolution is about four times greater than that of TOMS, OMI can also measure column amounts of trace gases important to ozone chemistry and air quality. The data from OMI can be used to map aerosols and estimate ultraviolet radiation reaching Earth's surface.

OMI was built by Dutch Space and TNO TPD in the Netherlands in co-operation with Finnish VTT and Patria Advanced Solutions Ltd. KNMI (Royal Netherlands Meteorological Institute) is the Principal Investigator Institute. Overall responsibility for the OMI mission lies with the Netherlands Agency for Aerospace Programmes (NIVR), with the participation of the Finnish Meteorological Institute (FMI).

OMI Contributions to Science Questions

Is the Stratospheric Ozone Layer Recovering?

OMI continues the 25-year satellite ozone record of SBUV and TOMS, mapping global ozone change (column amounts and profiles); data returned is used to support congressionally mandated and international ozone assessments. OMI has a broader wavelength range and better spectral resolution than previous ozone measuring instruments, and this should help scientists resolve differences among satellite and ground-based ozone measurements. OMI also measures the atmospheric column amounts of radicals such as nitrogen dioxide (NO₂), bromine oxide (BrO), and chlorine dioxide (OCIO).

Key OMI Facts

Heritage: Total Ozone Mapping Spectrometer (TOMS), Solar Backscatter Ultraviolet (SBUV), Global Ozone Monitoring Experiment (GOME), Scanning Imaging Absorption Spectrometer for Atmospheric Chartography (SCIAMACHY), Global Ozone Monitoring by Occultation of Stars (GOMOS)

Instrument Type: Wide-field imaging spectroradiometer

Scan Type: Non-scanning

Spectral Bands:

Visible: 350–500 nm

UV-1: 270–314 nm

UV-2: 306–380 nm

Spectral Resolution: 0.63–0.42 nm full width at half maximum (FWHM)

Spectral Sampling: 2–3 for FWHM

Dimensions: 50 cm × 40 cm × 35 cm

Mass: 46.06 kg

Power: 56 W (operational average)

Duty Cycle: 60 minutes on daylight side

Data Rate: 0.77 Mbps (average)

Telescope FOV: 114° (2600 km on ground)

IFOV: 3 km, binned to 13 km × 24 km

Detector: CCD, 780 × 576 (spectral × spatial) pixels

Pointing (arcsec)

(platform+instrument, pitch:roll:yaw, 3σ):

Accuracy: 275:275:275

Knowledge: 28:28:28

Stability (6 s): 28:28:28

Calibration: A white-light source is included onboard, as well as Light-Emitting Diodes (LEDs), a multi-surface solar-calibration diffuser, and a scrambler that scrambles the polarization from the back-scattered radiation.

Contributors

Industry Design and Assembly: Dutch Space (Netherlands), TNO (Netherlands), VTT (Finland), and Patria Advanced Solutions Ltd. (Finland)

Space Agencies and Funding: NIVR (Netherlands), with participation of FMI (Finland)

Responsible Centers: KNMI (Netherlands) and FMI (Finland)

What are the Processes Controlling Air Quality?

Tropospheric ozone, nitrogen dioxide, sulfur dioxide, and aerosols are four of the U.S. Environmental Protection Agency's six criteria pollutants. OMI maps tropospheric column totals of sulfur dioxide and aerosols. Scientists can take advantage of the synergistic nature of the Aura instruments and combine measurements from OMI, MLS, and HIRDLS, to produce maps of tropospheric ozone and nitrogen dioxide. In addition, OMI also measures the tropospheric ozone precursor formaldehyde. Scientists plan to use OMI measurements of ozone and cloud cover to derive the amount of ultraviolet (UV) radiation reaching Earth's surface. The National Weather Service will use OMI data to forecast high UV index days for public health awareness.

How is Earth's Climate Changing?

OMI tracks ozone, dust, smoke, biomass burning, and industrial aerosols in the troposphere. OMI's UV measurements allow scientists to better distinguish reflecting and absorbing aerosols, another important step forward in helping scientists more accurately represent aerosols in climate models.

OMI Principal Investigators

Pieter Levelt, Royal Netherlands Meteorological Institute (KNMI) (Netherlands)

Johanna Tamminen, Finnish Meteorological Institute (Finland)

Ernest Hilsenrath, NASA Goddard Space Flight Center (U.S.)

OMI URL

www.knmi.nl/omi

TES

Tropospheric Emission Spectrometer

TES Background

TES is a high-resolution infrared-imaging Fourier Transform Spectrometer with spectral coverage of 3.2–15.4 μm at a spectral resolution of 0.025/cm. The instrument can provide information on essentially almost all radiatively active gases in Earth's lower atmosphere, both night and day. TES makes both limb and nadir observations. In the limb mode, TES has a height resolution of 2.3 km, with coverage from the surface to 34 km altitude. In the nadir mode, TES has a spatial resolution of 5.3 km \times 8.5 km. The instrument can be pointed to any target within 45° of the local vertical. TES uses the same cryogenic refrigeration system described under HIRDLS to allow for detection of weak infrared radiation from Earth's atmosphere.

Key TES Facts

Heritage: Atmospheric Trace Molecule Spectroscopy experiment (ATMOS), Stratospheric Cryogenic Infrared Balloon Experiment (SCRIBE), Airborne Emission Spectrometer (AES)

Instrument Type: Infrared-Imaging Fourier Transform Spectrometer

Scan Type: Both limb and nadir scanning; fully targetable

Spectral Range: 3.2–15.4 μm , with four single-line arrays optimized for different spectral regions

Maximum Sampling Time: 16 s w/signal-to-noise ratio of up to 200:1

Swath: 5.3 km \times 8.5 km

Spatial Resolution: 0.53 km \times 5.3 km

Dimensions:

Stowed: 140 cm \times 130 cm \times 135 cm

Deployed: 304 cm \times 130 cm \times 135 cm

Mass: 385 kg

Thermal Control: 2 pulse-tube coolers, heater, radiators

Thermal Operating Range: 0–30° C

Power: 334 W

Duty Cycle: Variable

Data Rate: 6.2 Mbps (peak); 4.9 Mbps (average)

FOV: +45° to –72° along-track, \pm 45° cross-track

Instrument IFOV: 12 \times 7.5 mrad

Pointing Requirements

(platform+instrument, 3 σ):

Control: 156 arcsec (pitch)

Knowledge: 124 arcsec

Stability: 156 arcsec (over 50 s)

Calibration: On-board 340-K blackbody; cold space.

Responsible Center: NASA JPL

TES measures tropospheric ozone and many other gases important to tropospheric pollution. The presence of clouds in the atmosphere makes obtaining satellite tropospheric chemical observations more difficult, but the ability to make observations in the nadir and across the limb circumvents this problem. This observation capability provides measurements of the entire lower atmosphere, from the surface to the stratosphere.

TES Contributions to Science Questions

Is the Stratospheric Ozone Layer Recovering?

TES limb measurements extend from Earth's surface to the middle stratosphere, and the TES spectral range overlaps the spectral range of HIRDLS. As a result, TES's high-resolution spectra allow scientists to make measurements of some additional stratospheric constituents and also improve HIRDLS measurements of species common to both instruments.

What are the Processes Controlling Air Quality?

This is TES's primary focus. It measures the distribution of gases in the troposphere. TES can provide simultaneous measurements of tropospheric ozone and key gases involved in tropospheric ozone chemistry, such as CH₄, HNO₃ and CO. This information will serve as input for regional ozone-pollution models and will help to improve the accuracy and utility of these models.

How is Earth's Climate Changing?

TES measures tropospheric water vapor, methane, ozone and aerosols, all of which are relevant to climate change. In addition to this, other gases important to climate change can be retrieved from the TES spectra.

TES Principal Investigator

Reinhard Beer, NASA Jet Propulsion Laboratory/California Institute of Technology

TES URL

tes.jpl.nasa.gov/

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Aura Data Products

The data from Aura's four instruments are transmitted from the satellite ground stations and thence to the EOS Data and Operations System (EDOS). From there the raw data from HIRDLS, MLS, and OMI are sent to the Goddard Distributed Active Archive Center (DAAC); raw data from TES are sent to the Langley Research Center (LaRC) DAAC. Each Science Investigator-led Processing System (SIPS) receives data directly from the DAACs and processes it to produce scientific data such as profiles and column amounts of ozone and other important atmospheric species. Each instrument team monitors the data products to ensure that they are of high quality. The data products are then sent back to the DAACs, where they are archived. The DAACs are responsible for distribution of the data to scientists all over the world. Researchers, government agencies, and educators will have unrestricted access to the Aura data via the EOS data gateway. Data seekers can search for, and order data from, any of the EOS DAACs.

- *Goddard DAAC*: daac.gsfc.nasa.gov
- *Langley DAAC*: eosweb.larc.nasa.gov/

Product Name or Grouping	Processing Level	Coverage	Spatial/Temporal Characteristics
HIRDLS <i>Data Set Start Date: No data released as of May 2006</i>			
Radiances	1B	Global	70 km horizontal resolution (along track)
Temperature/Pressure Profile	2	Global for altitudes of 7–60 km	70 km horizontal resolution (along track), 1.25 km vertical resolution/ twice daily [day, night]
O ₃	2	Global, 7–55 km	70 km horizontal resolution (along track), 1.25 km vertical resolution/ twice daily [day, night]
H ₂ O Concentration	2	Global, 7–55 km	70 km horizontal resolution (along track), 1.25 km vertical resolution/ twice daily [day, night]
Aerosol Extinction Coefficient (4 Channels)	2	Global, 10–30 km	70 km horizontal resolution (along track), 1.25 km vertical resolution/ twice daily [day, night]
NO ₂	2	Global, 20–55 km	70 km horizontal resolution (along track), 1.25 km vertical resolution/ twice daily [day, night]
CH ₄ Concentration	2	Global, 10–60 km	70 km horizontal resolution (along track), 1.25 km vertical resolution/ twice daily [day, night]
CFC–11 (CFCl ₃) Concentration	2	Global, 7–28 km	70 km horizontal resolution (along track), 1.25 km vertical resolution/ twice daily [day, night]
CFC–12 (CF ₂ Cl ₂) Concentration	2	Global, 7–30 km	70 km horizontal resolution (along track), 1.25 km vertical resolution/ twice daily [day, night]
ClONO ₂	2	Global, 17–40 km	70 km horizontal resolution (along track), 1.25 km vertical resolution/ twice daily [day, night]
Cloud Top Height	2	Global, 7–24 km	70 km horizontal resolution (along track), 250 m vertical resolution/ twice daily [day, night]

Aura Data Products

Product Name or Grouping	Processing Level	Coverage	Spatial/Temporal Characteristics
HNO ₃ Concentration	2	Global, 10–40 km	70 km horizontal resolution (along track), 1.25 km vertical resolution/ twice daily [day, night]
N ₂ O Concentration	2	Global, 10–55 km	70 km horizontal resolution (along track), 1.25 km vertical resolution/ twice daily [day, night]
N ₂ O ₅ Concentration	2	Global, 20–45 km	70 km horizontal resolution (along track), 1.25 km vertical resolution/ twice daily [day, night]
Geopotential Height–Gradient	2	Global, 15–30 km	70 km horizontal resolution (along track)/ twice daily [day, night]
MLS <i>Data Set Start Date: August 8, 2004</i>			
Radiances	1B	Global for altitudes of 0–90 km	200 km horizontal resolution (along track), ~0.3–3 km vertical resolution/ twice daily [day, night]
Temperature	2, 3	Global, 5–90 km	200 km horizontal resolution, 2–3 km vertical resolution/ twice daily [day, night]
Geopotential Height	2, 3	Global, 5–90 km	200 km horizontal resolution, 2–3 km vertical resolution/ twice daily [day, night]
Cloud Ice Content	2	Global, 5–20 km	200 km horizontal resolution, 2–3 km vertical resolution/ twice daily [day, night]
H ₂ O Concentration	2, 3	Global, 5–90 km	200 km horizontal resolution, 2–3 km vertical resolution/ twice daily [day, night]
Relative Humidity (with respect to ice)	2, 3	Global, 5–90 km	200 km horizontal resolution, 2–3 km vertical resolution/ twice daily [day, night]
N ₂ O Concentration	2, 3	Global, 15–60 km	200 km horizontal resolution, ~3 km vertical resolution/ twice daily [day, night]
CO Concentration (stratosphere and above)	2, 3	Global, 15–90 km	200 km horizontal resolution, ~3 km vertical resolution/ twice daily [day, night]
CO Concentration (upper troposphere)	2, 3	Global, 8–15 km	200 km horizontal resolution, ~3 km vertical resolution/ twice daily [day, night]
O ₃ Concentration (stratosphere and above)	2, 3	Global, 15–80 km	200 km horizontal resolution, ~3 km vertical resolution/ twice daily [day, night]
O ₃ Concentration (upper troposphere)	2, 3	Global, 8–15 km	200 km horizontal resolution, ~3 km vertical resolution/ twice daily [day, night]

Aura Data Products

Product Name or Grouping	Processing Level	Coverage	Spatial/Temporal Characteristics
MLS			
OH Concentration (upper stratosphere)	2, 3	Global, 30–90 km	200 km horizontal resolution, ~3 km vertical resolution/ twice daily [day, night]
OH Concentration (lower stratosphere)	2, 3	Global, 18–30 km	10° lat. resolution, monthly zonal mean, ~3 km vertical resolution/ twice daily [day, night]
HO ₂ Concentration	2, 3	Global, 20–60 km	10° lat. resolution, monthly zonal mean, 5 km vertical resolution/ twice daily [day, night]
BrO Concentration	2, 3	Global, 20–60 km	10° lat. resolution, monthly zonal mean, 5 km vertical resolution/ twice daily [day, night]
ClO Concentration	2, 3	Global, 15–50 km	200 km horizontal resolution, ~3 km vertical resolution/ twice daily [day, night]
HCl Concentration	2, 3	Global, 15–60 km	200 km horizontal resolution, ~3 km vertical resolution/ twice daily [day, night]
HOCl Concentration	2, 3	Global, 20–50 km	10° lat. resolution, monthly zonal mean, 5 km vertical resolution/ twice daily [day, night]
HNO ₃ Concentration	2, 3	Global, 10–50 km	200 km horizontal resolution, ~3 km vertical resolution/ twice daily [day, night]
HCN Concentration	2, 3	Global, 25–65 km	horizontal resolution: 5° lat. for weekly zonal mean, 200 km for 30–40 km, ~3 km vertical resolution/twice daily [day, night]
SO ₂ Concentration (following large volcanic eruptions)	2	Global, 10–30 km	200 km horizontal resolution, ~3 km vertical resolution/ twice daily [day, night]
OMI <i>Data Set Start Date: August 17, 2004</i>			
Radiances	1B	Global	13 km × 24 km horizontal resolution/daily
Total Ozone	2	Global—total atmospheric column	13 km × 24 km horizontal resolution/daily
Ozone Profile	2	Global, for altitudes of 15–45 km	13 km × 48 km horizontal resolution, 6 km vertical resolution/daily
Surface UVB flux	2	Global—Earth's surface	13 km × 24 km horizontal resolution/daily
Cloud Scattering Layer Pressure	2	Global	13 km × 24 km horizontal resolution/daily
Aerosol Optical Thickness	2	Global—total atmospheric column	13 km × 24 km horizontal resolution/daily
Aerosol Single Scatterer Albedo	2	Global	13 km × 24 km horizontal resolution/daily
SO ₂	2	Global—total atmospheric column	13 km × 24 km horizontal resolution/daily

Aura Data Products

Product Name or Grouping	Processing Level	Coverage	Spatial/Temporal Characteristics
NO ₂	2	Global—total atmospheric column and tropospheric column	13 km × 24 km horizontal resolution/daily
HCHO	2	Global—total atmospheric column	13 km × 24 km horizontal resolution/daily
BrO	2	Global—total atmospheric column	13 km × 24 km horizontal resolution/daily
OCIO	2	Antarctic Polar Vortex region—slant column	13 km × 24 km horizontal resolution/daily
TES			
<i>Data Set Start Date: August 22, 2004</i>			
Level 1B Radiance, (IR spectra in selected bands 3.2–15.4 μm)	1B	Global	5.3 km × 8.3 km horizontal resolution/ every 16 days (compiled over alternate days)
CH ₄ Mixing Ratio	2	Global for altitudes of 0–34 km	5.3 km × 8.3 km horizontal resolution, 2–6 km vertical resolution/every 16 days (compiled over alternate days)
CO Mixing Ratio	2	Global, 0–34 km	5.3 km × 8.3 km horizontal resolution, 2–6 km vertical resolution/every 16 days (compiled over alternate days)
HNO ₃ Mixing Ratio	2	Global, 0–34 km	5.3 km × 8.3 km horizontal resolution, 2–6 km vertical resolution/every 16 days (compiled alternate days)
NO ₂ Mixing Ratio	2	Global, 0–34 km	5.3 km × 8.3 km horizontal resolution, 2–6 km vertical resolution/every 16 days (compiled over alternate days)
O ₃ Mixing Ratio	2	Global, 0–34 km	5.3 km × 8.3 km horizontal resolution, 2–6 km vertical resolution/every 16 days (compiled over alternate days)
H ₂ O Mixing Ratio	2	Global, 0–34 km	5.3 km × 8.3 km horizontal resolution, 2–6 km vertical resolution/every 16 days (compiled over alternate days)
Temperature Profile	2	Global, 0–34 km	5.3 km × 8.3 km horizontal resolution, 2–6 km vertical resolution/every 16 days (compiled over alternate days)
Land–Surface Temperature	2	Global, 0–34 km	5.3 km × 8.3 km horizontal resolution, 2–6 km vertical resolution/every 16 days (compiled over alternate days)

Aura Data Products