Aura

Science Writer's Guide

Is the stratospheric ozone layer recovering?

What are the processes controlling air quality?

How is the Earth's climate changing?

A guide for reporters to understand the mission and purpose of NASA's Aura Satellite

AURA IS DESIGNED TO ANSWER QUESTIONS ABOUT CHANGES IN OUR LIFE-SUSTAINING ATMOSPHERE:

1. IS THE STRATOSPHERIC OZONE LAYER RECOVERING?

2. WHAT ARE THE PROCESSES CONTROLLING AIR QUALITY?

3. HOW IS THE EARTH'S CLIMATE CHANGING?

Table of Contents

CREDITS

LEAD AUTHOR:
ROB GUTRO, SCIENCE SYSTEMS AND APPLICATIONS, INC. / NASA GODDARD SPACE FLIGHT CENTER

CONTRIBUTING AUTHORS AND EDITORS:
MARK SCHOEBERL, NASA GODDARD SPACE FLIGHT CENTER
ERNEST HILSENRATH, NASA GODDARD SPACE FLIGHT CENTER
ANNE DOUGLASS, NASA GODDARD SPACE FLIGHT CENTER
STEPHANIE STOCKMAN, SCIENCE SYSTEMS AND APPLICATIONS, INC. / NASA GODDARD
JEANNIE ALLEN, SCIENCE SYSTEMS AND APPLICATIONS, INC. / NASA GODDARD
RANI CHOHAN, NASA GODDARD SPACE FLIGHT CENTER

EDITORS:
GREG WILLIAMS, NASA HEADQUARTERS
LYNN CHANDLER, NASA GODDARD SPACE FLIGHT CENTER, PUBLIC AFFAIRS
MIKE BETTWY, CHARLOTTE GRINER AND KRISHNA RAMANUJAN, SCIENCE SYSTEMS AND APPLICATIONS, INC. / NASA GODDARD SPACE FLIGHT CENTER

LAYOUT AND DESIGN:
WINNIE HUMBERSON, SCIENCE SYSTEMS AND APPLICATIONS, INC. /NASA GODDARD SPACE FLIGHT CENTER

Aura Quick Reference Guide

NASA's Earth Observing System (EOS) Aura satellite is a NASA mission whose purpose is to study the Earth's ozone, air quality and climate. This mission is designed specifically to conduct research on the composition, chemistry and dynamics of the Earth's upper and lower atmosphere employing multiple instruments on a single satellite.

TO ANSWER MISSION AND SCIENCE QUESTIONS, CONTACT:

Aura Project Scientist:
Mark Schoeberl
NASA Goddard Space Flight Center
Mailstop 916.0
Greenbelt, MD 20771
301-614-6002
Mark.R.Schoeberl@nasa.gov

Aura Deputy Project Scientist:
Anne R. Douglass
NASA Goddard Space Flight Center
Mailstop 916.0
Greenbelt, MD 20771
301-614-6028
Anne.R.Douglass@nasa.gov

Aura Deputy Project Scientist:
Ernest Hilsenrath
NASA Goddard Space Flight Center
Mailstop 916.0
Greenbelt, MD 20771
301-614-6033
Ernest.Hilsenrath@nasa.gov

AURA RELATED PUBLICATIONS:
Aura Brochure - Publication # NP-2000-05-057-GSFC
Aura Fact Sheet - Publication # NP-2004-4-626-GSFC
Aura Lithograph
Aura Posters: 1) Educational 2) Science 3) Launch Vehicle Poster (by Boeing)
Aura Press Kit (fact sheet, press release, media information, quick facts on the spacecraft)
Fact sheets: *Formation Flying: The Afternoon A-Train Satellite Constellation* (FS-2003-1-053-GSFC); *Ozone* (FS-2001-1-014-GSFC [in English and Spanish]); *Aerosols* (FS-1999-06-022-GSFC).
To order, contact the EOS Project Science Office, NASA Goddard Space Flight Center, Code 900, Greenbelt, MD 20771, 301-867-2114
* ChemMatters: The Aura issues can be downloaded as PDF files from this page:
www.chemistry.org/portal/a/c/s/1/acsdisplay.html?DOC=education\curriculum\chemmatters\issue_arch.html

PUBLIC AND MEDIA AFFAIRS CONTACTS:

NASA Headquarters
Gretchen R. Cook-Anderson, Public Affairs
202-358-0836
Gretchen.Cook-Anderson@nasa.gov

NASA-TV (Video Requests)
Rani Chohan, TV Producer
301-286-2483
Rani.D.Chohan@nasa.gov

NASA Goddard Space Flight Center
Lynn Chandler, Aura Mission Public Affairs
301-286-2806
Lynn.Chandler-1@nasa.gov

NASA Jet Propulsion Laboratory
Alan Buis, Office of Media Relations
818-354-0474
alan.d.buis@jpl.nasa.gov

AURA WEB SITE: aura.gsfc.nasa.gov

AURA INSTRUMENT WEB SITES:
1) HIRDLS (High Resolution Dynamics Limb Sounder)
UCAR HIRDLS web site: www.eos.ucar.edu/hirdls/
UK Project Office web site: www.ssd.rl.ac.uk/hirdls/
2) MLS (Microwave Limb Sounder)
NASA JPL: mls.jpl.nasa.gov/
3) OMI (Ozone Monitoring Instrument)
Netherlands Weather, Climate and Seismology:
www.knmi.nl/omi/public_en/index_ pben.html
4) TES (Tropospheric Emission Spectrometer)
NASA JPL: tes.jpl.nasa.gov/

LINKS ON NASA'S EARTH OBSERVATORY WEB SITE ADDRESSING AURA SCIENCE QUESTIONS:
Ozone in the Stratosphere: earthobservatory.nasa.gov/Library/Ozone/
Ultraviolet Radiation: How It Affects Life on Earth: earthobservatory.nasa.gov/Library/UVB/
Effects of Surface Ozone on Humans and Plants: earthobservatory.nasa.gov/Library/OzoneWeBreathe/
Global Travels of Ozone in the Lower Atmosphere: earthobservatory.nasa.gov/Study/GlobalTraveler/
Tango in the Atmosphere (Ozone): earthobservatory.nasa.gov/Study/Tango/

NASA's VISION:

To improve life here

To extend life to there

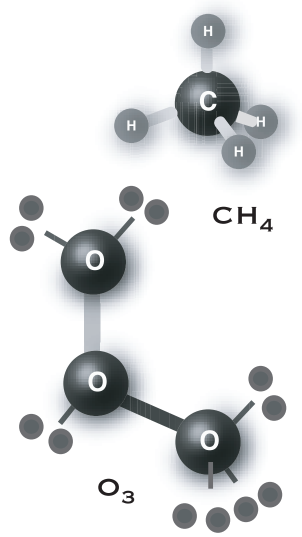
To Find life beyond

NASA's MISSION:

To understand and protect our home planet

To explore the universe and search for life

To inspire the next generation of explorers . . . as only NASA can.



Q&A on the Aura Mission

AURA IS DESIGNED TO ANSWER QUESTIONS ABOUT CHANGES IN OUR LIFE-SUSTAINING ATMOSPHERE:

1. IS THE STRATOSPHERIC OZONE LAYER RECOVERING?

2. WHAT ARE THE PROCESSES CONTROLLING AIR QUALITY?

3. HOW IS THE EARTH'S CLIMATE CHANGING?

WHAT IS AURA'S PURPOSE AND MISSION?
To study the Earth's ozone, air quality and climate. This mission is designed exclusively to conduct research on the composition, chemistry and dynamics of the Earth's upper and lower atmosphere by employing multiple instruments on a single satellite.

WHAT 3 STATEMENTS FORM THE BASIS FOR AURA'S OBJECTIVES?
1. The Earth's Ozone Shield protects all life.
2. The Earth's Air Quality is fundamental to public health and ecosystems.
3. The Earth's Climate is affected by changes in atmospheric composition.

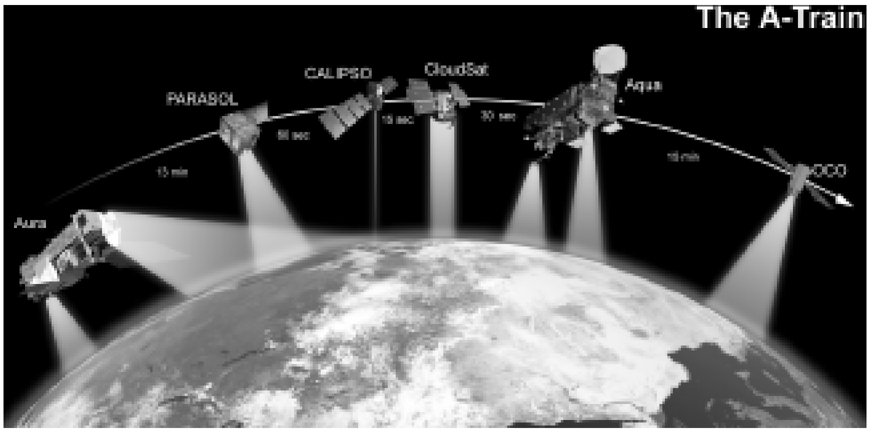
WHAT QUESTIONS WILL AURA ANSWER?
THE FEATURE SECTION OF THE WRITER'S GUIDE WILL EXPLORE:
Feature 1: Is the stratospheric ozone layer recovering?
Feature 2: What are the processes controlling air quality?
Feature 3: How is the Earth's climate changing?

WHAT PREVIOUS MISSIONS DOES AURA CONTINUE AND IMPROVE UPON?
The mission will continue the observations made by NASA's Upper Atmosphere Research Satellite (UARS) that uncovered key processes resulting in ozone depletion. It also extends the Total Ozone Mapping Spectrometer (TOMS) series of measurements, which accurately tracked global scale ozone changes over the last 22 years.
For more information about the previous atmospheric missions:
TOMS: jwocky.gsfc.nasa.gov/
UARS: umpgal.gsfc.nasa.gov/uars-science.html

WHAT MAKES AURA BETTER THAN PREVIOUS MISSIONS?
Aura's new objective over previous atmospheric research missions is to probe the Earth's troposphere, the region of the atmosphere (from the ground to about 10 km or 6 miles up) that most affects our daily lives.

HOW WILL ACCURACY OF AURA DATA BE ENSURED?
Aura will have an ambitious validation program, employing ground, balloon, aircraft, and other satellite data in various parts of the world, to ensure Aura data will meet the needs of the scientific community.

WHAT IS THE A-TRAIN OF SATELLITES?
By 2006, Aura will be a member of the "A-Train," a constellation of 6 Earth-observing satellites flying in a formation, including: Aqua, CloudSat, CALIPSO, and OCO. The French space agency, Centre National d'Etudes Spatiales (CNES), plans to send a sixth satellite, PARASOL, to join the A-Train. While each satellite has an independent science mission, these complementary satellite observations will enable scientists to obtain more comprehensive information.



This graphic shows the satellites that make up the Afternoon Constellation—"The A-Train." Listed under each satellite's name is its equator crossing time. (Credit: Alex McClung)

WHAT WILL THE A-TRAIN DO?

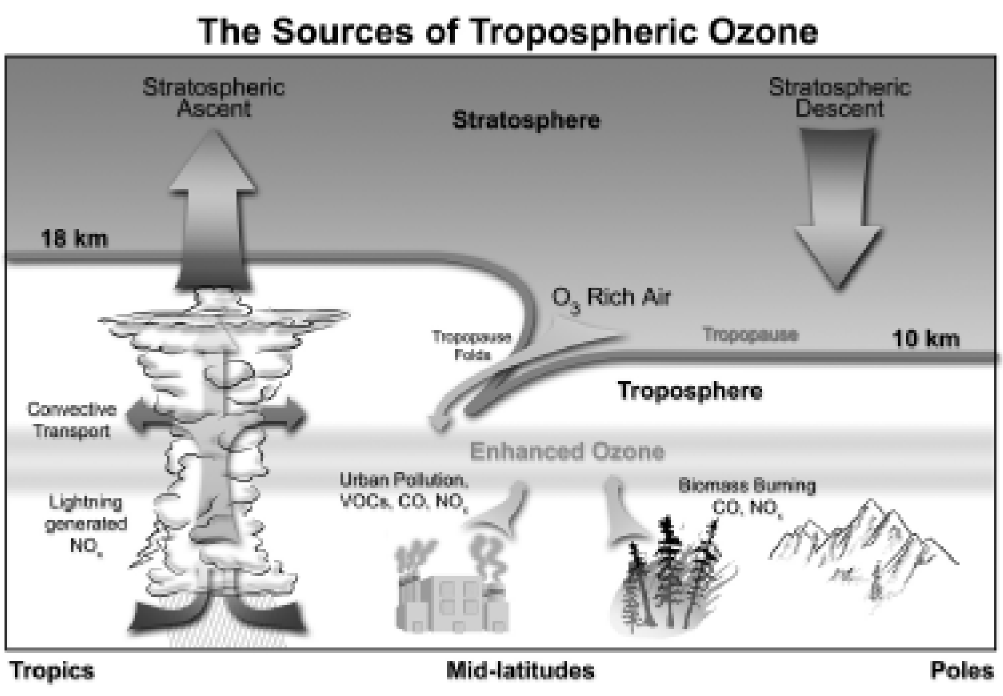
It will help identify aerosol types and determine how observations match global emission and transport models; study the role of polar stratospheric clouds in ozone loss in the Antarctic vortex; and study the vertical distribution of cloud water and ice in upper tropospheric cloud systems. Also see the Fact Sheet Formation Flying: The Afternoon "A-Train" Satellite Constellation (FS-2003-1-053-GSFC).

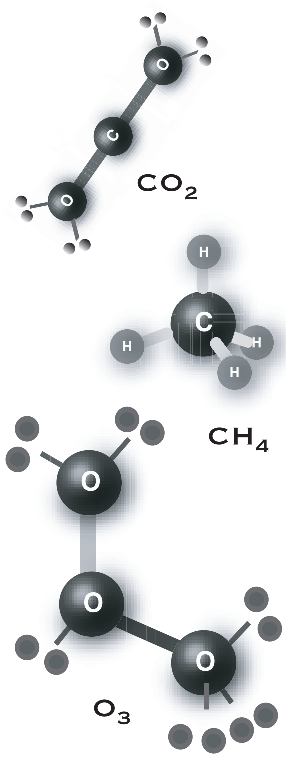
WHOM DO I CONTACT ABOUT OZONE, AIR QUALITY AND CLIMATE CHANGE QUESTIONS?

The Project Scientist or Deputy Project Scientists. (See page 1)

WHO CAN HELP WITH PRESS RELEASES, INTERVIEWS, OTHER RESOURCES? VIDEO?

Any NASA Public Affairs Office; NASA-TV for video requests. (See page 1)





Aura Spacecraft, Launch and Operation Quick Facts

AURA IS DESIGNED TO ANSWER QUESTIONS ABOUT CHANGES IN OUR LIFE-SUSTAINING ATMOSPHERE:

1. IS THE STRATOSPHERIC OZONE LAYER RECOVERING?

2. WHAT ARE THE PROCESSES CONTROLLING AIR QUALITY?

3. HOW IS THE EARTH'S CLIMATE CHANGING?

SPACECRAFT DIMENSIONS:

Stowed:	2.70 meters (8.8 ft) x 2.28 meters (7.5 ft) x 6.91 meters (22.7 ft)
Deployed:	4.70 meters (15.4 ft) x 17.37 meters (57.0 ft) x 6.91 meters (22.7 ft)
Weight at Launch:	2.967 kilograms (6,542 pounds)
Power:	4.6 kilowatts of electrical power from its solar array
Polar Orbit:	438 miles (705 kilometers)
Mission Lifetime:	Six years

SCIENCE INSTRUMENTS:

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

Launch Site:	Space Launch Complex (SLC 2) Western Range, Vandenberg Air Force Base, California
Expendable Launch Vehicle:	Boeing's Delta 7920-10L
Launch Date and Time:	June 19, 2004 at 3:01 a.m. PDT (6:01 a.m. EDT) (3-minute launch window)
Aura Spacecraft Separation:	Launch + 64 minutes 0 seconds
First Acquisition of Aura Signal:	Launch + 25 hours
Beginning of Science Operations:	September 28, 2004
Cost:	$785 million for Aura development costs, including launch vehicle
Spacecraft Builder/Integrator:	Northrop Grumman, Redondo Beach, California, under contract with NASA's Goddard Space Flight Center
Launch Vehicle/Operations:	NASA's Kennedy Space Center, Florida
Mission Management:	NASA's Goddard Space Flight Center, Greenbelt, Maryland

Basics on Ozone and Aerosols

Ozone Information Source: U.S. Environmental Protection Agency brochure #EPA-452/F-99-003. For information on Upper Atmospheric Ozone Depletion on the Internet, visit the U.S. EPA web site: www.epa.gov/ozone/resource/public.html.

WHAT IS OZONE? Ozone (O_3) is a gas composed of three oxygen atoms that occurs both in the Earth's upper atmosphere and at ground level. Ozone can be good or bad, depending on where it is found.

GOOD OZONE – Ozone occurs naturally in the Earth's upper atmosphere–10 to 30 miles above the Earth's surface, where it shields us from the Sun's harmful ultraviolet rays.

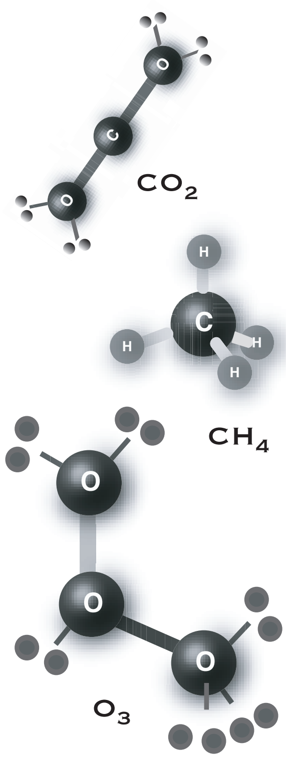
BAD OZONE – At ground level, ozone is created by a chemical reaction between oxides of nitrogen (NO_x) and volatile organic compounds (VOC) in the presence of heat and sunlight. Motor vehicle exhaust and industrial emissions, gasoline vapors, and chemical solvents are some of the major sources of NO_x and VOC that help form ozone. Sunlight and hot weather cause ground-level ozone to form in harmful concentrations in the air. As a result, it is known as a summertime air pollutant.

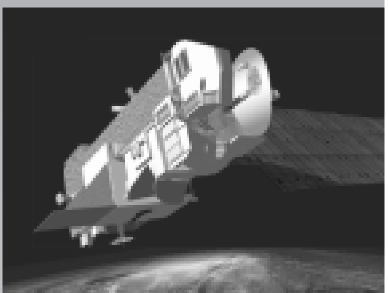
WHICH AREAS ARE SUBJECT TO BAD OZONE?
Many urban areas tend to have high levels of "bad" ozone, but even rural areas are subject to increased ozone levels because wind transports ozone and pollutants hundreds of miles away from their original sources.

WHAT IS THE OZONE LAYER AND WHY IS IT IMPORTANT?
The stratospheric ozone layer shields life on Earth from harmful solar ultraviolet (UV) radiation. About 90% of the planet's ozone is in the ozone layer. Stratospheric ozone is a naturally-occurring gas that filters the Sun's ultraviolet (UV) radiation. Excess exposure to UV radiation is harmful to agriculture, the marine food chain and causes skin cancer and eye problems.

WHAT CHEMICAL PROCESS OCCURS IN THE STRATOSPHERE WITH OZONE?
Intense UV radiation in the upper atmosphere produces ozone (O_3). The radiation breaks typical oxygen molecules (O_2) into free oxygen atoms (O). A free oxygen atom (O) can then join with an oxygen molecule (O_2) to form a molecule of ozone (O_3). Ozone absorbs UV, shielding the Earth from harmful rays.

WHAT DESTROYS OZONE?
Chemical reactions involving gases such as chlorine, bromine, nitrogen, and hydrogen destroy ozone. The ozone depletion over Antarctica results from the combined actions of very cold conditions, the return of sunlight in the Antarctic spring, and ozone depleting chemicals, which mostly come from human-produced compounds.





AURA IS DESIGNED TO ANSWER QUESTIONS ABOUT CHANGES IN OUR LIFE-SUSTAINING ATMOSPHERE:

1. IS THE STRATOSPHERIC OZONE LAYER RECOVERING?

2. WHAT ARE THE PROCESSES CONTROLLING AIR QUALITY?

3. HOW IS THE EARTH'S CLIMATE CHANGING?

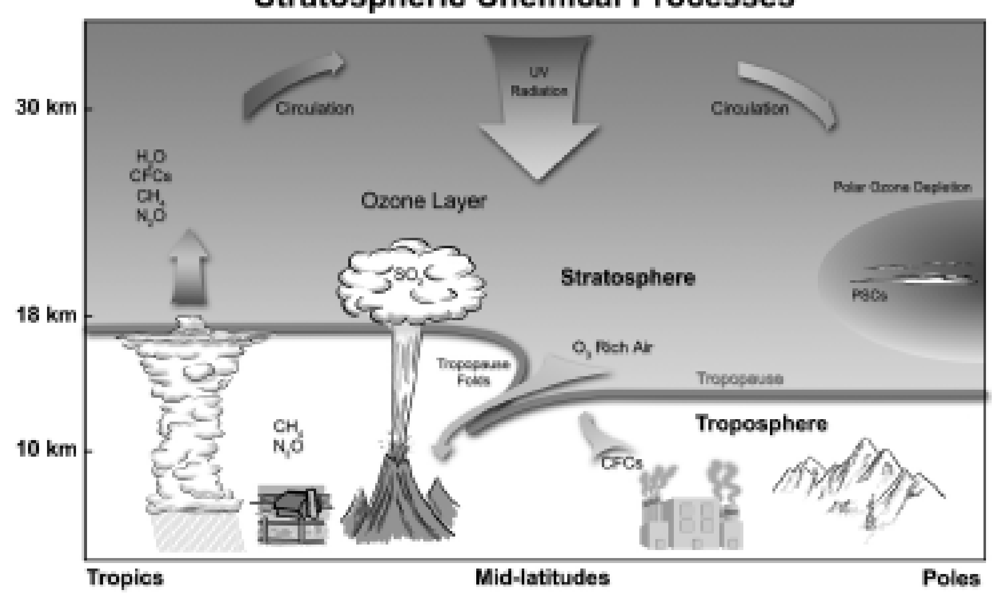
WHAT IS A DOBSON UNIT?
A Dobson unit is a measure of the amount of ozone in the atmosphere. The unit is named after G.M.B. Dobson, one of the first scientists to investigate atmospheric ozone (~1920 - 1960). He designed the 'Dobson Spectrometer' - the standard instrument used to measure ozone from the ground. The Dobson spectrometer measures the intensity of solar UV radiation at four wavelengths, two of which are absorbed by ozone and two that are not.

WHAT ARE AEROSOLS?
Aerosols are tiny particles suspended in the atmosphere, typically containing sulfur or carbon. Aerosols are emitted naturally (e.g., in volcanic eruptions) and as the result of human activities (e.g., by burning fossil fuels).

WHICH AEROSOLS HEAT, COOL?
Aerosols have a strong impact on climate. Dark colored aerosols (such as soot) absorb heat, thus creating conditions that may contribute to warming of a region's atmosphere. But, light colored aerosols can reflect sunlight, creating colder conditions.

DO AEROSOLS IMPACT CLIMATE?
Aerosols are an important but uncertain agent of climate change. Aerosols alter atmospheric temperatures by absorbing and scattering radiation, and can either warm or cool the troposphere. Aerosols also modify clouds and affect precipitation. Poor knowledge of the global distribution of aerosols contributes to a large uncertainty in climate prediction.

Stratospheric Chemical Processes



Aura – Part of NASA's Earth Observing System

The purpose of NASA's Earth Science Enterprise is to improve understanding of the total Earth system and the effects of natural and human-induced changes on the global environment. The NASA Office of Earth Science is pioneering the new interdisciplinary field of research called Earth system science, born of the recognition that the Earth's land surface, oceans, atmosphere, ice cover, and biota are dynamic and highly interactive. Earth Science Enterprise web site: www.earth.nasa.gov.

The Earth Science Enterprise is comprised of an integrated slate of spacecraft and in situ measurement capabilities; data and information management systems to acquire, process, archive, and distribute global data sets; and research to convert data into new knowledge of the Earth system. It is NASA's contribution to the U.S. Climate Change Science Program (www.climatescience.gov), an interagency effort to understand the processes and patterns of global change.

The centerpiece of the Earth Science Enterprise, the Earth Observing System (EOS), conceived in the 1980s, is a program of multiple spacecraft and interdisciplinary science investigations to provide key information needed to understand global climate change. The Terra satellite, launched in December 1999, was the flagship of EOS, and Aura is the third in the EOS series of large spacecraft.

The overall goal of the EOS program is to advance the understanding of the Earth system on a global scale by improving our knowledge of the components of the system, the interactions among them, and how the Earth system is changing. Specific EOS program mission goals are to: (1) create an integrated, scientific observing system emphasizing climate change that enables multi-disciplinary study of the Earth's critical, interrelated processes; (2) develop a comprehensive data and information system, including a data retrieval and processing system; (3) serve the needs of scientists performing an integrated multi-disciplinary study of planet Earth; and (4) acquire and assemble a global database of remote-sensing measurements from space over a decade or more to enable definitive and conclusive studies of the Earth system. We are well on the way to achieving these goals.

Terra, Aqua, and Aura are the three main EOS spacecraft that will support a broad range of scientific investigations. Each of these satellites is designed to operate for a period of at least six years. Additional observations are provided by Landsat 7, launched in April 1999, and several other more specialized missions. Some of these satellites will be flown in formation to simultaneously or sequentially monitor the same areas.

Nearly all U.S.-led EOS missions include international contributions. Terra, for example, includes the Canadian instrument Measurements of Pollution in the Troposphere (MOPITT) and the Japanese Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER). The Aqua mission includes the Japanese Advanced Microwave Scanning Radiometer (AMSR-E) and the Humidity Sounder for Brazil (HSB). The High Resolution Dynamics Limb Sounder (HIRDLS) instrument on board Aura is a joint U.S./U.K. development, and the Ozone Monitoring Instrument (OMI) is a Dutch-Finnish effort.

Earth Observing Satellite and Instrument Web sites

ACRIMSAT
acrim.jpl.nasa.gov/

Aqua
aqua.nasa.gov/

Aura
aura.gsfc.nasa.gov/

CALIPSO
www-calipso.larc.nasa.gov/

CloudSat
cloudsat.atmos.colostate.edu/

EO-1
eo1.gsfc.nasa.gov/

ERBS
asd-www.larc.nasa.gov/erbe/erbs.html

GRACE
www.csr.utexas.edu/grace/

ICESat
icesat.gsfc.nasa.gov/

Jason-1
topex-www.jpl.nasa.gov/mission/jason-1.html

Landsat 7
landsat.gsfc.nasa.gov/

Meteor 3M/SAGE III
www-sage3.larc.nasa gov/

QuikSCAT
winds.jpl.nasa.gov/missions/quikscat/index.cfm

SORCE
lasp.colorado.edu/sorce/

Terra
terra.nasa.gov/

TOMS- EP
toms.gsfc.nasa.gov/

TRMM
trmm.gsfc.nasa.gov/

UARS
umpgal.gsfc.nasa.gov/uars-science.html

Aura is designed to answer questions about changes in our life-sustaining atmosphere:

1. Is the stratospheric ozone layer recovering?

2. What are the processes controlling air quality?

3. How is the Earth's climate changing?

Several U.S. instruments are part of the payloads aboard satellites launched by other countries, including the Russian Meteor-3M and the French Jason-1 spacecraft.

In addition, numerous agreements have been signed for joint data exchange and distribution, including integration with the EOS Data and Information System (EOSDIS).

EOS sponsors many interdisciplinary research investigations that use specific Earth science data sets for broader investigation into the function of Earth systems. Current EOS research spans a wide range of sciences, including atmospheric chemistry, hydrology, land use, and marine ecosystems. The EOS Project Science Office at Goddard Space Flight Center consists of the Senior Project Scientist as well as Project Scientists associated with the various EOS missions and the EOSDIS. This office serves as the primary day-to-day interface between the Earth science community and the EOS projects at all NASA centers.

Complementing the EOS missions are a series of small, rapid development Earth System Science Pathfinder (ESSP) missions to study emerging science questions and to use innovative measurement techniques in support of EOS. The New Millennium Program (NMP) is designed to identify, develop, and validate key instrument and spacecraft technologies that can enable new or more cost-effective approaches to conducting science missions in the 21st Century.

Data from past and current Earth science missions are captured, processed into useful information, and broadly distributed by the EOSDIS. In addition to the EOSDIS, NASA is engaged in a variety of activities to extend the usefulness of Earth science data through a broad range of users such as Regional Earth Science Applications Centers and the Federation of Earth Science Information Partners.

The intellectual capital behind Earth science missions, and the key to generating new knowledge from them, is vested in an active program of research and analysis. The Earth Science Research and Analysis program funds more than 1,500 scientific research tasks.

Aura Features

The 3 Main Questions Aura Research Focuses On

1) IS THE STRATOSPHERIC OZONE LAYER RECOVERING?

The stratospheric ozone layer shields life on Earth from harmful solar ultraviolet (UV) radiation. Research has clearly shown that excess exposure to UV radiation is harmful to agriculture and causes skin cancer and eye problems. Excess UV radiation may suppress the human immune system.

Ozone is formed naturally in the stratosphere through break-up of oxygen molecules (O_2) by solar UV radiation. Individual oxygen atoms can combine with O_2 molecules to form ozone molecules (O_3). 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. The atmosphere maintains a natural balance between ozone formation and destruction.

The natural balance of chemicals in the stratosphere has changed, particularly due to the presence of man-made chlorofluorocarbons (CFCs). CFCs are non-reactive and accumulate in the atmosphere. They are destroyed in the high stratosphere where they are no longer shielded from UV radiation by the ozone layer.

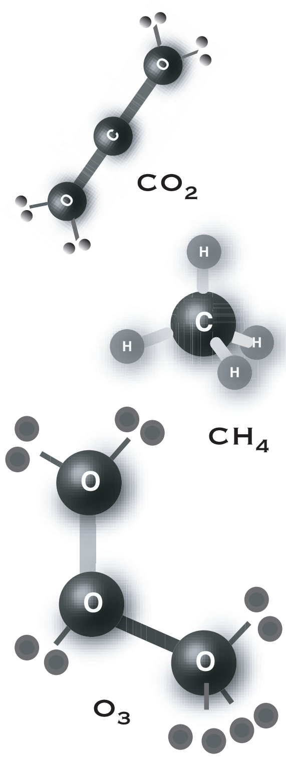
Destruction of CFCs yields atomic chlorine, an efficient catalyst for ozone destruction. Other man-made gases such as nitrous oxide (N_2O) and bromine compounds are broken down in the stratosphere and also participate in ozone destruction.

Satellite observations of the ozone layer began in the 1970s when the possibility of ozone depletion was just becoming an environmental concern. NASA's Total Ozone Mapping Spectrometer (TOMS) and Stratospheric Aerosol and Gas Experiment (SAGE) have provided long-term records of ozone. In 1985, the British Antarctic Survey reported an unexpectedly deep ozone depletion over Antarctica. The annual occurrence of this depletion, popularly known as the ozone hole, alarmed scientists.

Specially equipped high-altitude NASA aircraft established that the ozone hole was due to man-made chlorine. Data from the TOMS and SAGE satellites also showed smaller but significant ozone losses outside the Antarctic region. In 1987 an international agreement known as the Montreal Protocol restricted CFC production. In 1992, the Copenhagen amendments to the Montreal Protocol set a schedule to eliminate all production of CFCs.

Severe ozone depletion occurs in winter and spring over both polar regions. The polar stratosphere becomes very cold in winter because of the absence of sunlight and because strong winds isolate the polar air. Stratospheric temperatures fall below –88° C (-126.4° F). Polar stratospheric clouds (PSCs) form at these low temperatures. The reservoir gases HCl and $ClONO_2$ react on the surfaces of cloud particles and release chlorine.

Ground-based data have shown that CFC amounts in the troposphere are leveling off, while data from the Halogen Occultation Experiment (HALOE) on the Upper Atmosphere Research Satellite



Aura is designed to answer questions about changes in our life-sustaining atmosphere:

1. Is the stratospheric ozone layer recovering?

2. What are the processes controlling air quality?

3. How is the Earth's climate changing?

(UARS) have shown that amounts of HCl, a chlorine reservoir that is produced when CFCs are broken apart, are leveling off as well. Recent studies have shown that the rate of ozone depletion is also decreasing.

Recovery of the ozone layer may not be as simple as eliminating the manufacture of CFCs. Climate change will alter ozone recovery because greenhouse gas increases will cause the stratosphere to cool. This cooling may temporarily slow the recovery of the ozone layer in the polar regions, but will accelerate ozone recovery at low and middle latitudes.

What will Aura do?
Aura's instruments will observe the important sources, radicals, and reservoir gases active in ozone chemistry. Aura data will improve our capability to predict ozone change. Aura data will also help untangle the roles of transport and chemistry in determining ozone trends.

2) WHAT ARE THE PROCESSES CONTROLLING AIR QUALITY?

Agriculture and industrial activities have grown dramatically along with the human population. Conse-quently, in parts of the world, increased emissions of pollutants have significantly degraded air quality. Respiratory problems and even premature death due to air pollution occur in urban and some rural areas of both the industrialized and developing countries. Wide spread burning for agri-cultural purposes (biomass burning) and forest fires also contribute to poor air quality, particularly in the tropics.

The list of culprits in the degradation of air quality includes tropospheric ozone, a toxic gas, and the chemicals that form ozone. These ozone precursors are nitrogen oxides, carbon monoxide, methane, 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 criteria pollutants: carbon monoxide, nitrogen dioxide, sulfur dioxide, ozone, lead, and particulates (aerosols). Of these six pollutants, ozone has proved 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 for 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.

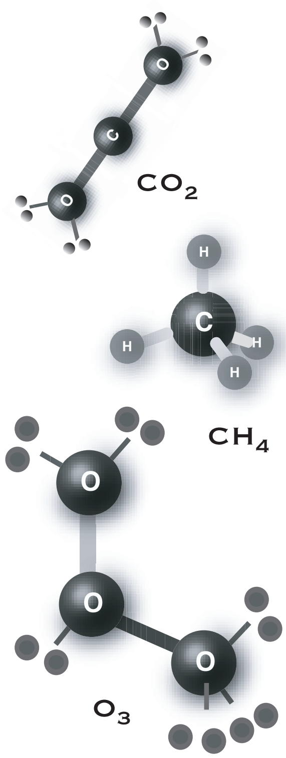
Observations and models show that pollutants from Southeast Asia contribute to poor air quality in India. Pollutants crossing from China to Japan reach the West Coast of the United States. Pollutants originating in the United States can reduce air quality in Europe.

Precursor gases for as much as 10% of ozone in surface air in the United States may originate outside the country. We have yet to quantify the extent of inter-regional and inter-continental pollution transport.

Long Range Pollution Transport
The atmosphere can transport pollutants long distances from their source. Satellite measurements by EOS Terra's MOPITT instrument have shown carbon monoxide streams extending almost 18,000 km (11,180 miles) from their source. TOMS has tracked dust and smoke events from northern China to the East Coast of the United States.

On July 7, 2002, MODIS on EOS-Terra and TOMS captured smoke from Canadian forest fires as the winds transported it southward. This pollution event was responsible for elevated surface ozone levels along the East Coast. TOMS has high sensitivity to aerosols like smoke and dust when they are elevated above the surface layers. OMI will be able to make similar measurements.

What will Aura do?
The Aura instruments are designed to study tropospheric chemistry; together Aura's instruments provide global monitoring of air pollution on a daily basis. They measure five of the six EPA criteria pollutants (all except lead). Aura will provide data of suitable accuracy to improve industrial emission inventories, and also to help distinguish between industrial and natural sources. Because of Aura, we will be able to improve air quality forecast models.



3) HOW IS EARTH'S CLIMATE CHANGING?

Carbon dioxide and other gases trap infrared radiation that would otherwise escape to space. This phenomenon, the greenhouse effect, makes the Earth habitable.

Increased atmospheric emissions from industrial and agricultural activities are causing climate change. Industry and agriculture produce trace gases that trap infrared radiation. Many of these gases have increased and thus have added to the greenhouse effect. Since the turn of the century, the global mean lower tropospheric temperature has increased by more than 0.4° Celsius (0.72° Fahrenheit). This increase has been greater than during any other century in the last 1000 years.

Ozone plays multiple roles in climate change, because it absorbs both ultraviolet radiation from the sun and infrared radiation from the Earth's surface. Tropospheric ozone is as important as methane as a greenhouse gas contributor to climate change. An accurate measurement of the vertical distribution of tropospheric ozone will improve climate modeling and climate predictions.

Aura is designed to answer questions about changes in our life-sustaining atmosphere:

1. Is the stratospheric ozone layer recovering?

2. What are the processes controlling air quality?

3. How is the Earth's climate changing?

Aerosols are an important but uncertain agent of climate change. Aerosols alter atmospheric temperatures by absorbing and scattering radiation. Aerosols can either warm or cool the troposphere. Therefore, aerosols also modify clouds and affect precipitation. Sulfate aerosols can reduce cloud droplet size, making clouds brighter so that they reflect more solar energy. Black carbon aerosols strongly absorb solar radiation, warming the mid-troposphere and reducing cloud formation. Poor knowledge of the global distribution of aerosols contributes to a large uncertainty in climate prediction.

Ozone absorbs solar radiation, warming the stratosphere. Man-made chlorofluorocarbons have caused ozone depletion, leading to lower temperatures. Low temperatures, in turn, lead to more persistent polar stratospheric clouds and cause further ozone depletion in polar regions.

Increasing carbon dioxide (CO_2) also affects the climate of the upper atmosphere. Where the atmosphere is thin, increasing CO_2 emits more radiation to space, thus cooling the environment. Observations show that over recent decades, the mid- to upper-stratosphere has cooled by 1 to 6° Celsius (2 to 11° Fahrenheit) due to increases in CO_2. This cooling will produce circulation changes in the stratosphere that will change how trace gases are transported.

Water vapor is an important greenhouse gas. Some measurements suggest that water vapor is increasing in the stratosphere. This increase may be due to changes in the transport of air between the troposphere and the stratosphere caused by climate change, or it could be due to changes in the microphysical processes within tropical clouds. More measurements of upper tropospheric water vapor, trace gases and particles are needed to untangle the cause and effect relationships of these various agents of climate change. We can verify climate models of the atmosphere only with global observations of the atmosphere and its changes over time.

What will Aura do?

Aura will measure greenhouse gases such as methane, water vapor, and ozone in the upper troposphere and lower stratosphere. Aura also will measure both absorbing and reflecting aerosols in the lower stratosphere and lower troposphere, water vapor measurements inside high tropical clouds, and 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.

Aura's Four Instruments

Aura's four instruments will give scientists a complete view of the atmosphere never before seen.

Snapshot of Aura Instruments and What They Look At

ACRONYM	*NAME*	WHAT THE INSTRUMENT MONITORS
HIRDLS	High Resolution Dynamics Limb Sounder	Profiles of T, O_3, H_2O, CH_4, N_2O, NO_2, HNO_3, N_2O_5, CF_3Cl, CF2 Cl_2, $ClONO_2$, aerosol composition
MLS	Microwave Limb Sounder	Profiles of T, H_2O, O_3, ClO, BrO, HCl, OH, HO_2, HNO_3, HCN, N_2O, CO, cloud ice, HOCl, CH_3CN
OMI	Ozone Monitoring Instrument	Column O_3, aerosols, NO_2, SO_2, BrO, OClO, HCHO, UV-B, cloud top pressure, O_3 profiles
TES	Tropospheric Emission Spectrometer	Profiles of T, O_3, NO_2, CO, HNO_3, CH_4, HO

Aura Instrument Descriptions

High Resolution Dynamics Limb Sounder (HIRDLS)

HIRDLS is an infrared limb-scanning radiometer measuring trace gases, temperature, and aerosols in the upper troposphere, stratosphere, and mesosphere.

The instrument will provide critical information on atmospheric chemistry and climate. Using vertical and horizontal limb scanning technology, HIRDLS will provide accurate measurements with daily global coverage at high vertical and horizontal resolution. The University of Colorado, the National Center for Atmospheric Research (NCAR), Oxford University (UK) and Rutherford Appleton Laboratory (UK) designed the HIRDLS instrument. Lockheed Martin built and integrated the instrument subsystems. The National Environmental Research Council funded the United Kingdom participation.

BrO
Bromine monoxide
CF_2Cl_2
Dichlorodifluoromethane
$CFCl_3$
Trichlorofluoromethane
CH_3CN
Methyl cyanide
CH_4
Methane
Cl
Chlorine
ClO
Chlorine monoxide
$ClONO_2$
Chlorine nitrate
CO
Carbon monoxide
CO_2
Carbon dioxide
H_2O
Water
HCl
Hydrogen chloride
HCHO
Formaldehyde
HCN
Hydrogen Cyanide
HNO_3
Nitric acid
HO_2
Hydroperoxy radical
HOCl
Hypochlorous acid
N_2O
Nitrous oxide
N_2O_5
Dinitrogen pentoxide
NO
Nitric oxide
NO_2
Nitrogen dioxide
NO_x
Nitrogen oxide
O_2
Oxygen
O_3
Ozone
OClO
Chlorine dioxide
OH
Hydroxyl
SO_2
Sulfur dioxide

Aura is designed to answer questions about changes in our life-sustaining atmosphere:

1. Is the stratospheric ozone layer recovering?

2. What are the processes controlling air quality?

3. How is the Earth's climate changing?

HIRDLS Contributions to Understanding Stratospheric Ozone
The largest ozone depletions occur in the polar winter lower stratosphere. HIRDLS will retrieve high vertical resolution daytime and nighttime ozone profiles in this region.

HIRDLS will measure NO_2, HNO_3 and CFCs, 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 will make it possible to assess the transport of air from the troposphere into the stratosphere.

HIRDLS Contributions to Understanding Air Quality
HIRDLS will measure ozone, nitric acid, and water vapor in the upper troposphere and lower stratosphere. With these measurements, scientists will be able to estimate the amount of stratospheric air that descends into the troposphere and will allow us to separate natural ozone pollution from man-made sources.

HIRDLS Contributions to Understanding Climate Change
HIRDLS will measure water vapor and ozone, both important greenhouse gases. The instrument is also able to distinguish between aerosol types that absorb or reflect incoming solar radiation. HIRDLS will be able to map high thin cirrus clouds that reflect solar radiation.

HIRDLS Web sites:
UCAR: www.eos.ucar.edu/hirdls/
UK Project Office: www.ssd.rl.ac.uk/hirdls/

Microwave Limb Sounder (MLS)

MLS is a limb scanning emission microwave radiometer. MLS measures radiation in the Gigahertz (GHz) and Terahertz (THz) frequency ranges (millimeter and sub-millimeter wavelengths). Aura's MLS is a major technological advance over the MLS flown on UARS. MLS will measure important ozone-destroying chemical species in the upper troposphere and stratosphere. In addition, MLS has a unique ability to measure trace gases in the presence of ice clouds and volcanic aerosols. NASA's Jet Propulsion Laboratory (JPL) developed, built, tested, and will operate MLS.

MLS Contributions to Understanding Stratospheric Ozone
Aura's MLS will continue the ClO and HCl measurements made by UARS. These measurements will inform us about the rate at which stratospheric chlorine is destroying ozone. MLS will also provide the first global measurements of the stratospheric hydroxyl (OH) and hydroperoxy (HO_2) radicals that are part of the hydrogen catalytic cycle for ozone destruction. In addition, MLS will measure bromine monoxide (BrO), a powerful ozone-destroying radical. BrO has both natural and man-made sources.

MLS measurements of ClO and HCl will be especially important in the polar regions. The HCl measurements tell scientists how stable chlorine reservoirs are converted to the ozone destroying radical, ClO. Since the Arctic stratosphere may now be at a threshold for more severe ozone loss, Aura's MLS data will be especially important.

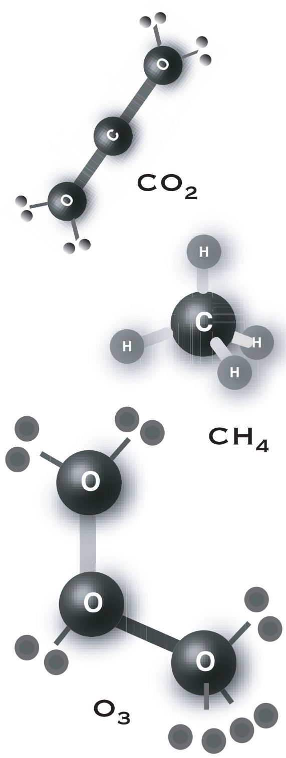
MLS Contributions to Understanding Air Quality
MLS measures carbon monoxide (CO) and ozone in the upper troposphere. CO is an important trace gas that can indicate the exchange of air between the stratosphere and troposphere. CO is also a tropospheric ozone precursor and its appearance in the upper troposphere can reveal strong vertical transport from pollution events.

MLS Contributions to Understanding Climate Change
MLS's measurements of upper tropospheric water vapor, ice content, and temperature will be used to reduce the uncertainty in climate forcing. MLS also measures greenhouse gases such as ozone and N_2O in the upper troposphere.

MLS Web site:
NASA JPL: mls.jpl.nasa.gov/

Ozone Monitoring Instrument (OMI)

OMI is a nadir viewing spectrometer that measures solar reflected and backscattered light in a selected range of the ultraviolet and visible spectrum. The instrument's 2600 km (1,616 mile) viewing swath is perpendicular to the orbit track, providing complete daily coverage of the sunlit portion of the atmosphere. OMI is Aura's primary instrument for tracking global ozone change and will continue the high quality column ozone record begun in 1970 by Nimbus-4 BUV.



OMI has a broader wavelength range and better spectral resolution and will also measure column amounts of trace gases important to ozone chemistry and air quality. OMI will map aerosols and estimate ultraviolet radiation reaching the Earth's surface. OMI's horizontal resolution is about four times greater than TOMS.

The Netherlands Agency for Aerospace Programs (NIVR) and the Finnish Meteorological Institute (FMI) contributed the OMI instrument to the Aura mission. The Netherlands companies, Dutch Space and TNO-TPD, together with Finnish companies, Patria, VTT and SSF, built the instrument.

OMI Contributions to Understanding Stratospheric Ozone
OMI will continue the 34-year satellite ozone record of SBUV and TOMS, mapping global ozone change. OMI data will support congressionally mandated and international ozone assessments. Using its broad wavelength range and spectral resolution, OMI scientists will have more accurate measurements to resolve the differences among satellite and ground-based ozone measurements.

Aura is designed to answer questions about changes in our life-sustaining atmosphere:

1. Is the stratospheric ozone layer recovering?

2. What are the processes controlling air quality?

3. How is the Earth's climate changing?

OMI Contributions to Understanding Air Quality
OMI will also measure the atmospheric column of radicals such as nitrogen dioxide (NO_2) and chlorine dioxide (OClO). Tropospheric ozone, nitrogen dioxide, sulfur dioxide, and aerosols are four of the U.S. Environmental Protection Agency's six criteria pollutants. OMI will map tropospheric columns of sulfur dioxide and aerosols. OMI measurements will be combined with information from MLS and HIRDLS to produce maps of tropospheric ozone and nitrogen dioxide.

OMI will also measure the tropospheric ozone precursor, formaldehyde. Scientists will use OMI measurements of ozone and cloud cover to derive the amount of ultraviolet radiation (UV) reaching the Earth's surface. The National Weather Service will use OMI data to forecast high UV index days for public health awareness.

OMI Contributions to Understanding Climate Change
OMI tracks dust, smoke and industrial aerosols in the troposphere. OMI's UV measurements allow scientists to distinguish reflecting and absorbing aerosols and will help improve climate models.

OMI Web site:
Netherlands Weather, Climate and Seismoloy:
www.knmi.nl/omi/public_en/index_pben.html

Tropospheric Emission Spectrometer (TES)

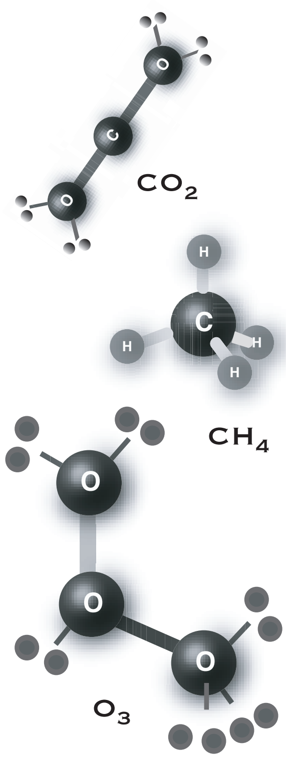
TES is an imaging Fourier Transform Spectrometer observing the thermal emission of the Earth's surface and atmosphere, night and day. TES will measure tropospheric ozone directly and other gases important to tropospheric pollution with very high horizontal resolution. TES has a higher resolution than OMI, but with less coverage. Satellite tropospheric chemical observations are difficult to make due to the presence of clouds. To overcome this problem, TES was designed to observe both downward (in the nadir) and horizontally (across the limb). This observation capability provides measurements of the entire lower atmosphere, from the surface to the stratosphere. NASA's JPL developed, built, tested, and will operate TES. The TES primary objective is to measure trace gases associated with air quality.

TES Contributions to Understanding Stratospheric Ozone
TES limb measurements extend from the 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 will allow scientists to make measurements of some additional stratospheric constituents as well as improve HIRDLS measurements of species common to both instruments.

TES Contributions to Understanding Air Quality
TES will measure the distribution of gases in the troposphere. TES will provide simultaneous measurements of tropospheric ozone and key gases involved in tropospheric ozone chemistry, such as CH_4, HNO_3 and CO. TES data will be used to improve regional ozone pollution models.

TES Contributions to Understanding Climate Change
TES will measure tropospheric water vapor, methane, ozone and aerosols, all of which are relevant to climate change. Additional gases important to climate change can be retrieved from the TES spectra.

TES Web site:
NASA JPL: tes.jpl.nasa.gov/



AURA IS DESIGNED TO ANSWER QUESTIONS ABOUT CHANGES IN OUR LIFE-SUSTAINING ATMOSPHERE:

1. IS THE STRATOSPHERIC OZONE LAYER RECOVERING?

2. WHAT ARE THE PROCESSES CONTROLLING AIR QUALITY?

3. HOW IS THE EARTH'S CLIMATE CHANGING?

Information Resources

Please call the NASA Public Affairs Office before contacting individual scientists.
NASA Goddard Space Flight Center: Lynn Chandler, 301-286-2806; or
Alan Buis at NASA Jet Propulsion Laboratory 818-354-0474.

Contact Information for Mission and Science Questions

Aura Program Management:
Dr. Philip L. DeCola, Program Scientist
NASA Headquarters
Washington, DC 20546-0001
202-358-2770
pdecola@nasa.gov

Aura Project Scientist:
Dr. Mark Schoeberl, Project Scientist
NASA Goddard Space Flight Center
Mailstop 916.0
Greenbelt, MD 20771
301-614-6002
Mark.R.Schoeberl@nasa.gov

Aura Deputy Project Scientists:
Dr. Anne R. Douglass
NASA Goddard Space Flight Center
Mailstop 916.0
Greenbelt, MD 20771
301-614-6028
Anne.R.Douglass@nasa.gov

Dr. Ernest Hilsenrath
NASA Goddard Space Flight Center
Mailstop 916.0
Greenbelt, MD 20771
301-614-6033
Ernest.Hilsenrath@nasa.gov

Contacts for Aura Instrument Team Scientists:

HIRDLS - High Resolution Dynamics Limb Sounder

For questions on the HIRDLS instrument and function, check for the Science Team Member closest to your location.

Principal Investigators
Dr. John Gille (U.S. Principal Investigator)
Center for Limb Atmospheric Sounding
University of Colorado/
National Center for Atmospheric Research (NCAR)
P.O. Box 3000
Boulder, CO 80307-3000
301-497-1402
gille@ucar.edu

Dr. John J. Barnett (U.K. Principal Investigator)
Department of Physics
Oxford University
j.barnett1@physics.ox.ac.uk

United States Co-Investigators
Prof. Linnea Avallone (Co-Investigator)
Laboratory for Atmospheric and Space Physics
University of Colorado
avallone@lasp.colorado.edu

Dr. Guy Brasseur (Co-Investigator)
Atmospheric Chemistry Division
NCAR
brasseur@ucar.edu

Dr. Byron A. Boville (Co-Investigator)
Climate and Global Dynamics Division
NCAR
boville@ucar.edu

Dr. Michael T. Coffey (Co-Investigator)
Atmospheric Chemistry Division
NCAR
coffey@ucar.edu

Dr. Prof. Brian Toon (Co-Investigator)
Laboratory for Atmospheric and Space Physics
University of Colorado
toon@lasp.colorado.edu

United Kingdom Co-Investigators
Dr. D.G. Andrews (Co-Investigator)
Department of Physics
Oxford University
d.andrews1@physics.ox.ac.uk

Dr. R.S. Harwood (Co-Investigator)
Department of Meteorology
Edinburgh University
r.s.harwood@ed.ac.uk

Dr. M.E. McIntyre (Co-Investigator)
Department of Applied Mathematics and Theoretical Physics
Cambridge University
enquiries@damtp.cam.ac.uk

Dr. H.G. Muller (Co-Investigator)
Department of Physics
Sheffield University

Dr. C.T. Mutlow (Co-Investigator)
Rutherford Appleton Laboratory
c.mutlow@rutherford.ac.uk

Dr. A. O'Neill (Co-Investigator)
Department of Meteorology
Reading University
alan@met.reading.ac.uk

Dr. J.A. Pyle (Co-Investigator)
Department of Physical Chemistry
Cambridge University
pyle@atm.ch.cam.ac.uk

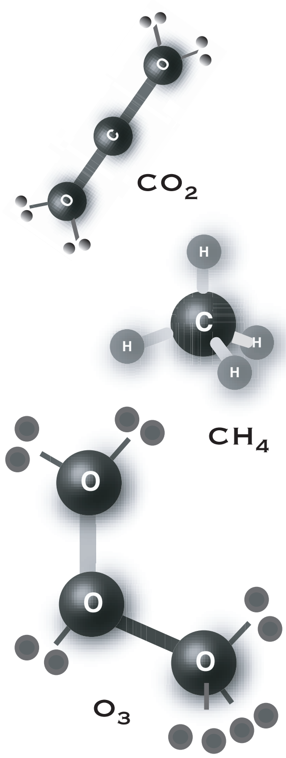
Dr. J.S. Seely (Co-Investigator)
Department of Cybernetics
Reading University

Prof. F.W. Taylor (Co-Investigator)
Department of Physics
Oxford University
f.taylor1@physics.ox.ac.uk

Dr. G. Vaughan (Co-Investigator)
Department of Physics
University College of Wales
gxv@aber.ac.uk

Mr. J.G. Whitney (HIRDLS System Engineer)
Department of Physics
Oxford University
j.whitney1@physics.ox.ac.uk

Dr. E.J. Williamson (Co-Investigator)
Department of Physics
Oxford University
j.williamson1@physics.ox.ac.uk



AURA IS DESIGNED TO ANSWER QUESTIONS ABOUT CHANGES IN OUR LIFE-SUSTAINING ATMOSPHERE:

1. IS THE STRATOSPHERIC OZONE LAYER RECOVERING?

2. WHAT ARE THE PROCESSES CONTROLLING AIR QUALITY?

3. HOW IS THE EARTH'S CLIMATE CHANGING?

Please call the NASA Public Affairs Office before contacting individual scientists.
NASA Goddard Space Flight Center: Lynn Chandler, 301-286-2806; or
Alan Buis at NASA Jet Propulsion Laboratory 818-354-0474.

MLS - Microwave Limb Sounder

For questions on the MLS instrument and function, check for the Science Team Member closest to your location.

Dr. Joe Waters (MLS Principal Investigator)
NASA Jet Propulsion Laboratory
Mailstop 183-701
4800 Oak Grove Drive
Pasadena, CA 91109-8099
818-354-3025
Joe.W.Waters@jpl.nasa.gov

MLS Co-Investigators
Dr. Richard E. Cofield (optics engineer and field-of-view calibration scientist)
NASA Jet Propulsion Laboratory
Mailstop 183-701
4800 Oak Grove Drive
Pasadena, CA 91109-8099
818-354-2501
rick@mls.jpl.nasa.gov

Dr. David T. Cuddy (Science Software and Data Production Manager)
NASA Jet Propulsion Laboratory
Mailstop 183-701
4800 Oak Grove Drive
Pasadena, CA 91109-8099
818-354-2099
David.T.Cuddy@jpl.nasa.gov

Dr. Mark J. Filipiak (CO & upper tropospheric products)
Institute of Atmospheric and Environmental Science
School of GeoSciences
University of Edinburgh
EDINBURGH EH9 3JZ, Scotland, UK
44-131-650-8743
mjf@met.ed.ac.uk

Dr. Dennis A. Flower (EOS MLS Project Manager)
NASA Jet Propulsion Laboratory
Mailstop 264-658
4800 Oak Grove Drive
Pasadena, CA 91109-8099
818-354-4151
flower@mls.jpl.nasa.gov

Dr. Lucien Froidevaux (lead scientist for overall validation of MLS atmospheric data; responsible for MLS stratospheric ozone data and EOS MLS HCl and HOCl)
NASA Jet Propulsion Laboratory
Mailstop 183-701
4800 Oak Grove Drive
Pasadena, CA 91109-8099
818-354-8301
lucien@mls.jpl.nasa.gov

Dr. Robert S. Harwood (UK MLS Principal Investigator)
Institute of Atmospheric and Environmental Science
School of GeoSciences
University of Edinburgh
EDINBURGH EH9 3JZ, Scotland, UK
+44-131-650-5095
harwood@met.ed.ac.uk

Dr. Robert F. Jarnot (MLS Instrument Scientist)
NASA Jet Propulsion Laboratory
Mailstop 183-701
4800 Oak Grove Drive
Pasadena, CA 91109-8099
818-354-5204
jarnot@mls.jpl.nasa.gov

Dr. Richard R. Lay (UARS MLS operations engineer; EOS MLS functional verification and operations cognizant engineer)
NASA Jet Propulsion Laboratory
Mailstop 183-701
4800 Oak Grove Drive
Pasadena, CA 91109-8099
818-354-3541
lay@mls.jpl.nasa.gov

Dr. Nathaniel J. Livesey (Retrieval theory and EOS MLS N_2O, BrO, and CH_3CN)
NASA Jet Propulsion Laboratory
Mailstop 183-701
4800 Oak Grove Drive
Pasadena, CA 91109-8099
818-354-4214
livesey@mls.jpl.nasa.gov

Dr. Gloria L. Manney (JPL Senior Research Scientist)
Department of Natural Sciences
New Mexico Highlands University
Las Vegas, NM 97701
505-454-3364
manney@mls.jpl.nasa.gov

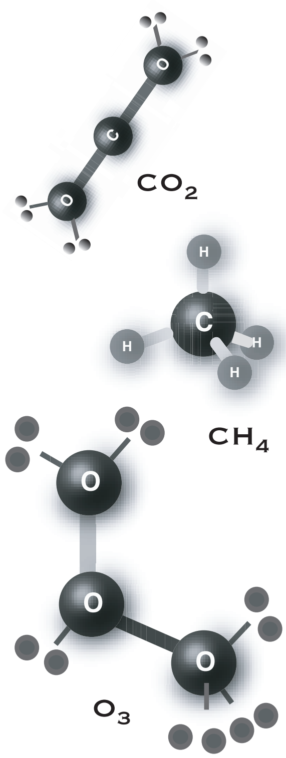
Dr. Herbert M. Pickett (Scientist responsible for EOS MLS OH and HO_2 measurement and spectral line catalog used by MLS)
NASA Jet Propulsion Laboratory
Mailstop 183-701
4800 Oak Grove Drive
Pasadena, CA 91109-8099
818-354-6861
hmp@spec.jpl.nasa.gov

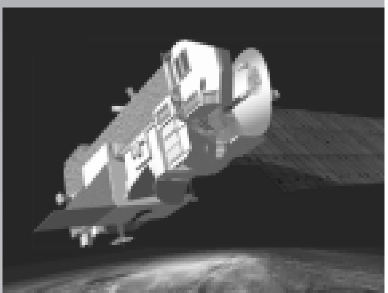
Dr. Hugh C. Pumphrey (Stratospheric H_2O and HCN)
Institute of Atmospheric and Environmental Science
School of GeoSciences
University of Edinburgh
EDINBURGH EH9 3JZ, Scotland, UK
+44-131-650-6026
H.C.Pumphrey@ed.ac.uk

Dr. William G. Read (Lead scientist for MLS forward model, upper tropospheric H_2O and SO_2)
NASA Jet Propulsion Laboratory
Mailstop 183-701
4800 Oak Grove Drive
Pasadena, CA 91109-8099
818-354-6773
bill@thak.jpl.nasa.gov

Dr. Michelle L. Santee (Polar process studies; responsible for UARS MLS HNO_3 and EOS MLS HNO_3 and ClO)
NASA Jet Propulsion Laboratory
Mailstop 183-701
4800 Oak Grove Drive
Pasadena, CA 91109-8099
818-354-9424
mls@praxis.jpl.nasa.gov

Dr. Dong L. Wu (Atmospheric gravity wave and cirrus ice products and UARS MLS temperature, tangent pressure, and geopotential height validation)
NASA Jet Propulsion Laboratory
Mailstop 183-701
4800 Oak Grove Drive
Pasadena, CA 91109-8099
818-393-1954
dwu@mls.jpl.nasa.gov





AURA IS DESIGNED TO ANSWER QUESTIONS ABOUT CHANGES IN OUR LIFE-SUSTAINING ATMOSPHERE:

1. IS THE STRATOSPHERIC OZONE LAYER RECOVERING?

2. WHAT ARE THE PROCESSES CONTROLLING AIR QUALITY?

3. HOW IS THE EARTH'S CLIMATE CHANGING?

**Please call the NASA Public Affairs Office before contacting individual scientists.
NASA Goddard Space Flight Center: Lynn Chandler, 301-286-2806; or
Alan Buis at NASA Jet Propulsion Laboratory 818-354-0474.**

OMI - Ozone Monitoring Instrument

For questions on the OMI instrument and function, check for the Science Team Member closest to your location.

Dr. P.F. Levelt (KNMI) (Principal Investigator)
The Netherlands
levelt@knmi.nl

Dr. G.W. Leppelmeier (FMI) (Finnish Co-Principal Investigator)
Finland
gwl@GandS.pp.fi

Dr. Ernest Hilsenrath (U.S. Co-Principal Investigator)
NASA Goddard Space Flight Center
Mailstop 916.0
Greenbelt, MD 20771
301-614-6033
Ernest.Hilsenrath@nasa.gov

TES - Tropospheric Emission Spectrometer

For questions on the TES instrument and function, check for the Science Team Member closest to your location.

Dr. Reinhard Beer (Principal Investigator)
NASA Jet Propulsion Laboratory
Mailstop 183-601
4800 Oak Grove Drive
Pasadena, CA 91109-8099
818-354-4748
Reinhard.Beer@jpl.nasa.gov

TES Science Investigators
Dr. Michael R. Gunson (Deputy Principal Investigator)
NASA Jet Propulsion Laboratory
Mailstop 183-601
4800 Oak Grove Drive
Pasadena, CA 91109-8099
818-354-2124
Michael.R.Gunson@jpl.nasa.gov

Dr. Shepard A. Clough (Retrieval algorithms; Validation)
Atmospheric & Environmental Research, Inc.
781-761-2282
clough@aer.com

Dr. Daniel J. Jacob (Tropospheric Chemistry; Modeling)
Harvard University
617-495-1794
djj@io.harvard.edu

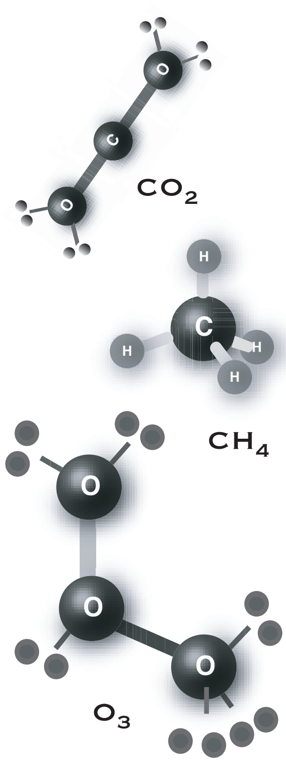
Dr. Jennifer A. Logan (Tropospheric Chemistry; Modeling)
Harvard University
617-495-4582
jal@io.harvard.edu

Dr. Curtis P. Rinsland (Spectroscopy; Validation)
NASA Langley Research Center
757-864-2699
c.p.rinsland@larc.nasa.gov

Dr. Clive D. Rodgers (Retrieval Algorithms)
Oxford University
+44-1865-272905
rodgers@atm.ox.ac.uk

Dr. Stanley P. Sander (Tropospheric Chemistry)
NASA Jet Propulsion Laboratory
818-354-2625
Stanley.P.Sander@jpl.nasa.gov

Dr. Helen M. Worden (Algorithm Team Leader; AES Analysis)
NASA Jet Propulsion Laboratory
818-354-0532
hmw@tes-mail.jpl.nasa.gov



Aura Educational Outreach

Aura is designed to answer questions about changes in our life-sustaining atmosphere:

1. Is the stratospheric ozone layer recovering?

2. What are the processes controlling air quality?

3. How is the Earth's climate changing?

The Aura project supports a strong educational and public outreach (E&PO) effort through educational partnerships with organizations that are leaders in science education and communication including the Smithsonian Institution's National Museum of Natural History (NMNH), American Chemical Society (ACS), and the Global Learning and Observations to Benefit the Environment (GLOBE) program. Our goal is to educate students and the public and to inform industry and policy makers how Aura will lead to a better understanding of the global environment.

The National Museum of Natural History, working with Aura scientists will design and create an interactive exhibit on atmospheric chemistry as part of its "Forces of Change" program. NMNH will convey the role of atmospheric chemistry in our lives through the use of remote-sensing visualizations and museum objects.

The American Chemical Society produced three special issues of the publication ChemMatters that focus on the chemistry of the atmosphere and various aspects of the Aura mission, and a fourth will follow. The special editions of ChemMatters will reach approximately 30,000 U.S. high school chemistry teachers and students.

The GLOBE program is a worldwide network of students, teachers (10,000 schools in more than 95 countries), and scientists working together to study the global environment. As part of GLOBE, Drexel University will support measurements taken from the Aura spacecraft with ground-based instruments designed to collect data on ultraviolet-A (UV-A) radiation and aerosols. A tropospheric ozone measurement developed by NASA's Langley Research Center is also a GLOBE protocol.

Aura's E&PO program will also have a strong presence at science and environmental fairs and science and technology conferences to demonstrate Aura's unique role in NASA's program to study the Earth's environment.

For more information about Aura educational outreach, contact Stephanie Stockman, stockman@core2.gsfc.nasa.gov, 301-614-6457

Aura Education and Outreach Web site Addresses:

1. Chem Matters online: www.acs.org/education/curriculum/chemmatt.html
2. Educational opportunity information: eos-aura.gsfc.nasa.gov
3. GLOBE Program online: www.globe.gov/fsl/welcome/welcomeobject.pl
4. National Museum of Natural History online: www.nmnh.si.edu/

Aura Print Material and NASA Earth Science Web Sites

Aura Related Publications

- Aura Brochure - Publication # NP-2000-05-057-GSFC
- Aura Fact Sheet
- Aura Lithograph
- Aura Posters: 1) Educational 2) Science 3) Launch Vehicle Poster (by Boeing)
- Aura Press Kit (fact sheet, press release, media information, quick facts on the spacecraft)
- Fact sheets: Formation Flying: The Afternoon A-Train Satellite Constellation (FS-2003-1-053-GSFC); Ozone (FS-2001-1-014-GSFC [in English and Spanish]); Aerosols (FS-1999-06-022-GSFC).

* ChemMatters: The Aura issues can be downloaded as PDF files from this page: www.chemistry.org/portal/a/c/s/1/acsdisplay.html?DOC=education\curriculum\chemmatters\issue_arch.html

To order, contact: The EOS Project Science Office, NASA Goddard Space Flight Center, Code 900, Greenbelt, MD 20771, 301-867-2114

Aura Instrument Web Sites

HIRDLS (High Resolution Dynamics Limb Sounder)
UCAR: www.eos.ucar.edu/hirdls/
UK Project Office: www.ssd.rl.ac.uk/hirdls/

MLS (Microwave Limb Sounder)
NASA JPL: mls.jpl.nasa.gov/

OMI (Ozone Monitoring Instrument)
Netherlands Weather, Climate and Seismology: www.knmi.nl/omi/public_en/index_pben.html

TES (Tropospheric Emission Spectrometer)
NASA JPL: tes.jpl.nasa.gov/

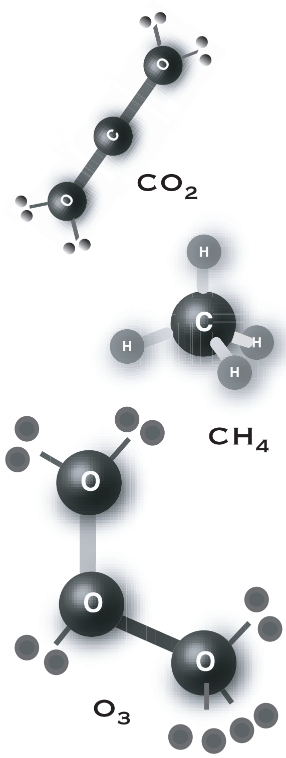
Other NASA Earth Science Web Sites:
Destination Earth: www.earth.nasa.gov/

The web site of NASA's Earth Science Enterprise in Washington, D.C., contains information about the agency's entire Earth science program. The "Science of the Earth System" section of the site describes the agency's major research themes: atmospheric chemistry, hydrological and energy cycle, land cover and land use, ozone, natural hazards and the solid Earth, and climate variability and change. The "Earth Science Missions" section provides links to all major spacecraft missions and instruments as well as the Earth Probes program, the New Millennium missions, and commercial remote sensing.

Earth Observatory
earthobservatory.nasa.gov
The Earth Observatory presents articles, images, and animations that illustrate the complexities of Earth system science as well as NASA's use of satellite-based and other remote-sensing data to study change on global and regional scales. Updated daily, the Earth Observatory is an information resource for educators, the media and general public.

EOS Project Science Office
eos.gsfc.nasa.gov/
The EOS Project Science Office (EOSPSO) web site presents program information and resources for the entire EOS program. It is appropriate for both EOS program scientists and the general public.

Visible Earth
visibleearth.nasa.gov/
Visible Earth is a searchable directory of images, visualizations, and animations of the Earth. It features an extensive library of print and broadcast quality images on agriculture, atmosphere, biosphere, cryosphere, human dimensions, hydrosphere, land surface, oceans, radiance imagery, and solid Earth, in various locations.



Aura is designed to answer questions about changes in our life-sustaining atmosphere:

1. Is the stratospheric ozone layer recovering?

2. What are the processes controlling air quality?

3. How is the Earth's climate changing?

Other Earth Science Spacecraft and Instrument Web Sites

ACRIMSAT
acrim.jpl.nasa.gov/
A series of U.S. Active Cavity Radiometer Irradiance Monitors (ACRIMs), the latest launched December 20, 1999, provide long-term, precise measurements of the total amount of the Sun's energy that falls on our planet's surface, oceans, and atmosphere.

Aqua
aqua.nasa.gov/ or aqua.gsfc.nasa.gov/
Aqua was so named because it obtains significant information about the Earth's water cycle, including ocean surface water, snow, ice, water vapor, clouds, precipitation, and soil moisture. Aqua was launched May 4, 2002.

Aura
aura.gsfc.nasa.gov/
The Aura satellite will focus on measurements of atmospheric trace gases and their transformations. The primary objective of the mission is to study the chemistry and dynamics of the Earth's atmosphere from the ground through the mesosphere. Aura is scheduled for launch in 2004.

CALIPSO
www-calipso.larc.nasa.gov/
Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO) will provide key measurements of aerosol and cloud properties needed to improve climate predictions. CALIPSO will fly in formation with Aqua and CloudSat to obtain coincident observations of radiative fluxes and atmospheric states. This comprehensive set of measurements is essential for accurate quantification of global aerosol and cloud radiative effects. CALIPSO is scheduled for launch in 2005.

CloudSat
cloudsat.atmos.colostate.edu/
CloudSat's primary goal is to furnish data needed to evaluate and improve the way clouds are parameterized in global models, leading to improved cloud predictions. The new data will increase current understanding of the role clouds play in climate change, referred to as cloud-climate feedback. CloudSat is scheduled for launch in 2005.

EO-1
eo1.gsfc.nasa.gov/
One of the key responsibilities of NASA's Earth Science Enterprise is to ensure the continuity of future Landsat data. The New Millennium Program's (NMP) first flight, Earth Observing-1 (EO-1), is validating technologies contributing to the reduction in cost of follow-on Landsat missions. The Hyperion instrument is aboard this spacecraft. EO-1 was launched November 21, 2001.

ERBS
asd-www.larc.nasa.gov/erbe/erbs.html
The Earth Radiation Budget Satellite (ERBS) investigates how energy from the Sun is absorbed and re-emitted by the Earth. Observations from ERBS are also used to determine the effects of human activities (such as the burning of fossil fuels and the use of CFCs) and natural occurrences, such as volcanic eruptions on the Earth's radiation balance. Launched in October 1984, the satellite is currently partially operational.

GRACE
www.csr.utexas.edu/grace/
The first of the Pathfinder missions, the Gravity Recovery and Climate Experiment (GRACE)

employs a satellite-to-satellite microwave tracking system to measure the Earth's gravity field and its time variability over five years. Such measurements are directly coupled to long-wavelength ocean circulation processes and to the transport of ocean heat to the Earth's poles. GRACE was launched March 17, 2002.

ICESat
icesat.gsfc.nasa.gov/
The Ice, Cloud, and Land Elevation Satellite (ICESat) is a small U.S. satellite mission to fly the Geoscience Laser Altimeter System (GLAS) in a near-polar orbit. GLAS will accurately measure the elevation of the Earth's ice sheets, clouds, and land. ICESat was launched January 12, 2003.

Jason-1
topex-www.jpl.nasa.gov/mission/jason-1.html
Jason-1 is a joint U.S.-France (Centre National d' Etudes Spatiales) oceanography mission designed to monitor global ocean circulation, quantify the tie between the oceans and atmosphere, improve global climate predictions, and monitor events such as El Niño and La Niña and ocean eddies. Jason-1 was launched December 7, 2001.

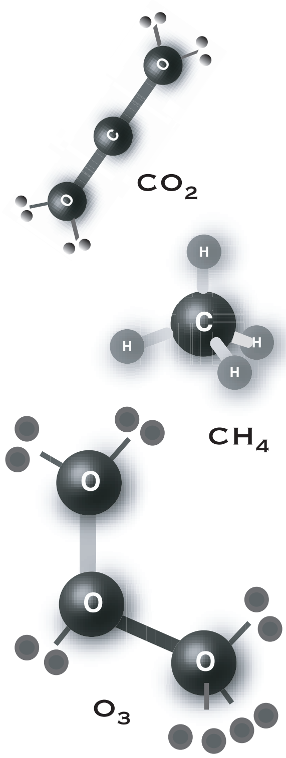
Landsat 7
landsat.gsfc.nasa.gov/ or
landsat7.usgs.gov/index.php
Landsat 7 is a U.S. satellite used to acquire remotely-sensed images of the Earth's land surface and surrounding coastal regions and is the longest running enterprise for acquisition of imagery of the Earth from space. The first Landsat satellite was launched in 1972. Landsat 7 was launched April 15, 1999.

Meteor-3M/SAGE III
www-sage3.larc.nasa.gov/
The Stratospheric Aerosol and Gas Experiment 3 (SAGE III) is a fourth generation, satellite-borne instrument and a crucial element in NASA's Earth Observing System (EOS). Its mission is to enhance our understanding of natural and human-derived atmospheric processes by providing accurate long-term measurements of the vertical structure of aerosols, ozone, water vapor, and other important trace gases in the upper troposphere and stratosphere. SAGE III was launched December 10, 2001.

QuikSCAT
winds.jpl.nasa.gov/missions/quikscat/index.cfm
The SeaWinds instrument on the Quick Scatterometer (QuikSCAT) mission is a "quick recovery" mission to fill the gap created by the loss of data from the NASA Scatterometer (NSCAT) in June 1997. The SeaWinds instrument is a specialized microwave radar that measures near-surface wind speed and direction under all weather and cloud conditions over the Earth's oceans. QuikSCAT was launched June 19, 1999.

SORCE
lasp.colorado.edu/sorce/
The SOLar STellar Irradiance Comparison Experiment (SOLSTICE) and Total Irradiance Monitor (TIM) aboard the Solar Radiation and Climate Experiment (SORCE) provide the scientific community with long-term, accurate measurements of the solar ultraviolet (UV), far ultraviolet (FUV), and total irradiance from the Sun. SORCE was launched January 25, 2003.

Terra
terra.nasa.gov/
The Terra satellite is the flagship of EOS and provides global data on the state of the atmosphere, land, and oceans, as well as their interactions with solar radiation.



Aura is designed to answer questions about changes in our life-sustaining atmosphere:

1. Is the stratospheric ozone layer recovering?

2. What are the processes controlling air quality?

3. How is the Earth's climate changing?

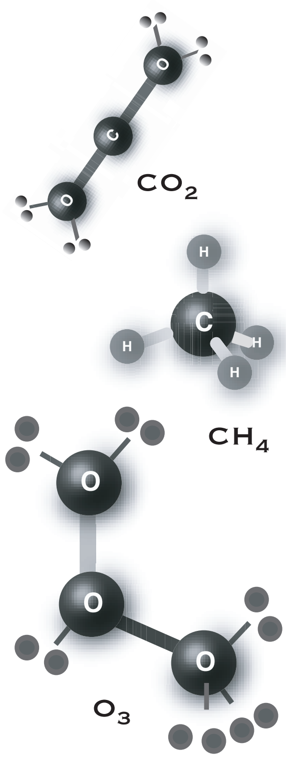
TOMS- EP
toms.gsfc.nasa.gov/
The missions of the Total Ozone Mapping Spectrometer (TOMS) included four spacecraft and the participation of three nations, the U.S., Russia and Japan. The TOMS instrument was aboard the Nimbus 7 satellite, the Meteor-3M, ADEOS, and Earth Probe. TOMS provides global measurements of total column ozone and its variation on a daily basis.

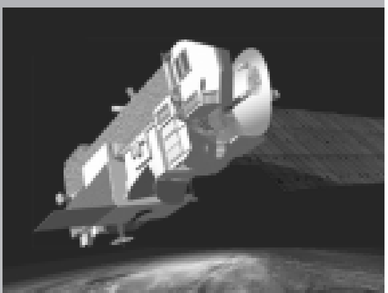
TRMM
trmm.gsfc.nasa.gov/
The Tropical Rainfall Measuring Mission (TRMM) is a joint mission between NASA and the Japan Aerospace Exploration Agency (JAXA) designed to monitor and study tropical rainfall. TRMM was launched November 27, 1997.

UARS
umpgal.gsfc.nasa.gov/uars-science.html
The Upper Atmospheric Research Satellite (UARS) is the first NASA mission that carried out a systematic, comprehensive study of the stratosphere and furnishes important new data on the mesosphere and thermosphere. The United Kingdom, Canada and France provided some of the instruments for this mission. UARS was launched in 1991.

Acronyms

ACS	American Chemical Society
ASTER	Advanced Spaceborne Thermal Emission and Reflection Radiometer
ASTR	Along Track Scanning Radiometer
BUV	Backscatter Ultraviolet Instrument
CALIPSO	Cloud-Aerosol Lidar and Infrared Pathfinder Satellite
CCD	Charge Coupled Device
CFC	Chlorofluorocarbon
CNES	Centre National d'Etudes Spatiales
DAAC	Distributed Active Archive Center
DFRC	Dryden Flight Research Center
DU	Dobson Unit
EOC EOS	Operations Center
EOS Earth	Observing System
EOSDIS	Earth Observing System Data and Information System
EPA	Environmental Protection Agency
ESA	European Space Agency
GISS	Goddard Institute for Space Studies
GLOBE	Global Learning and Observations to Benefit the Environment
GOME	Global Ozone Monitoring Experiment
GSFC	Goddard Space Flight Center
HALOE	Halogen Occultation Experiment, instrument on UARS satellite
HIRDLS	High Resolution Dynamics Limb Sounder (One of the four Aura instruments)
JPL	Jet Propulsion Laboratory
KNMI	Royal Dutch Meteorological Institute
MLS	Microwave Limb Sounder (One of the four Aura instruments)
MODIS	Moderate-resolution Imaging Spectroradiometer
MOPITT	Measurements of Pollution in the Troposphere
NASA	National Aeronautics and Space Administration
NCAR	National Center for Atmospheric Research
NDSC	Network for the Detection of Stratospheric Change
NGST	Northrop Grumman Space Technology
Nimbus-7	NASA satellite, operated from 1978-1994 carrying a TOMS instrument
Nimbus-4	NASA satellite operated from 1970-1980 carrying the BUV instrument
NOAA	National Oceanic and Atmospheric Administration
OCO	Orbiting Carbon Observatory
OMI	Ozone Monitoring Instrument (One of the four Aura instruments)
OMPS	Ozone Mapping Profiler Suite
PARASOL	Polarization and Anisotropy of Reflectances for Atmospheric Sciences coupled with Observations from a Lidar
ppbv	Parts per billion volume
SAGE	Stratospheric Aerosol and Gas Experiment
SBUV	Solar Backscatter Ultraviolet
SCIAMACHY	Scanning Imaging Absorption Spectrometer for Atmospheric Cartography
SIPS	Science Investigator Processing Systems
SSAI	Science Systems & Applications, Inc.
TES	Tropospheric Emission Spectrometer (One of the four Aura instruments)
TOMS	Total Ozone Mapping Spectrometer
UARS	Upper Atmosphere Research Satellite
UK	United Kingdom
UMBC	University of Maryland Baltimore County
UV	Ultraviolet
VOC	Volatile Organic Compound





AURA IS DESIGNED TO ANSWER QUESTIONS ABOUT CHANGES IN OUR LIFE-SUSTAINING ATMOSPHERE:

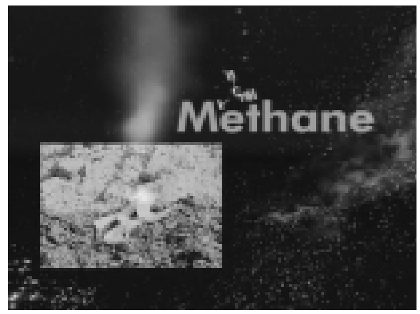
1. IS THE STRATOSPHERIC OZONE LAYER RECOVERING?

2. WHAT ARE THE PROCESSES CONTROLLING AIR QUALITY?

3. HOW IS THE EARTH'S CLIMATE CHANGING?

Symbols for Chemicals Aura Examines

BrO	Bromine monoxide
CF_2Cl_2	Dichlorodifluoromethane
$CFCl_3$	Trichlorofluoromethane
CH_3CN	Methyl cyanide
CH_4	Methane
Cl	Chlorine
ClO	Chlorine monoxide
$ClONO_2$	Chlorine nitrate
CO	Carbon monoxide
CO_2	Carbon dioxide
H_2O	Water
HCl	Hydrogen chloride
HCHO	Formaldehyde
HCN	Hydrogen Cyanide
HNO_3	Nitric acid
HO_2	Hydroperoxy radical
HOCl	Hypochlorous acid
N_2O	Nitrous oxide
N_2O_5	Dinitrogen pentoxide
NO	Nitric oxide
NO_2	Nitrogen dioxide
NO_x	Nitrogen oxide
O_2	Oxygen
O_3	Ozone
OClO	Chlorine dioxide
OH	Hydroxyl
SO_2	Sulfur dioxide



Methane is a simple compound made of carbon and hydrogen. This gas comes from ordinary sources, like cattle herds and garbage dumps. On a planetary scale it also has a significant impact on climate. As it builds up in the atmosphere, it traps energy from the sun like a layer of insulation.

Carbon dioxide, such as that created from emissions by using fossil fuels does much the same thing as methane because it causes global warming by trapping heat.

Aura's instruments will detect aerosols, and their characteristics, emitted from industrial activity, biomass burning, and volcanoes. Aerosols can either reflect or absorb solar radiation and either heat or cool the atmosphere and contribute to climate change.

WHAT'S THE AURA SATELLITE ALL ABOUT? WHY SHOULD THE PUBLIC CARE ABOUT AURA?

http://aura.gsfc.nasa.gov/

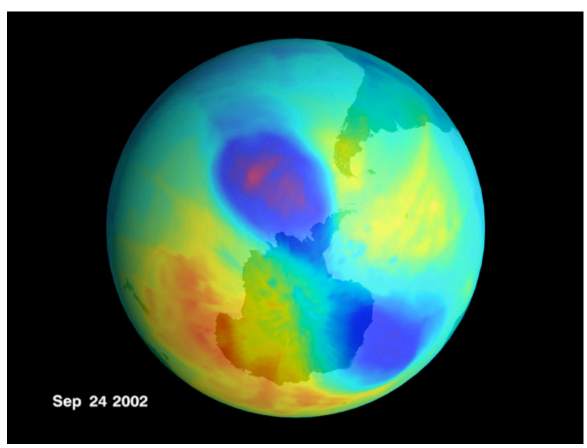
NASA next-generation Earth-observing satellite, Aura, will revolutionize the way we study and understand changes in our climate, our air quality, and the ozone layer.

The Aura satellite will provide us the first global view of the Earth's atmosphere, an essential stepping stone to better understanding the Moon, Mars and beyond.

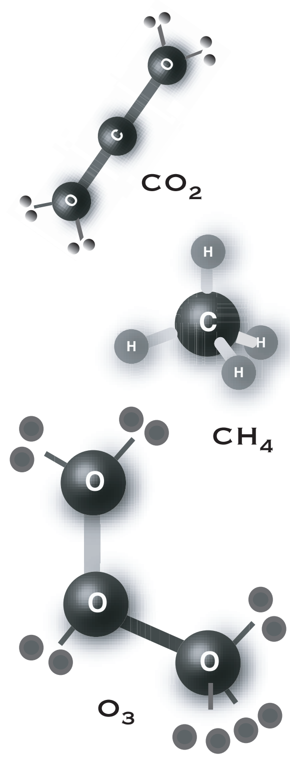
NASA's launch of the Aura satellite is a challenging endeavor, a mission on the cutting edge of scientific discovery characteristic of the agency's legacy of ground-breaking exploration.

With the Aura mission, NASA will cap off a 15-year international effort to establish the world's most comprehensive Earth Observing System, whose overarching goal is to determine the extent, causes, and regional consequences of global change.

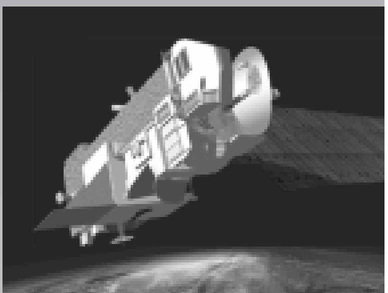
THE BOTTOM LINE:
NASA's Aura is a Mission to understand and protect the air we breathe



Notes



Notes

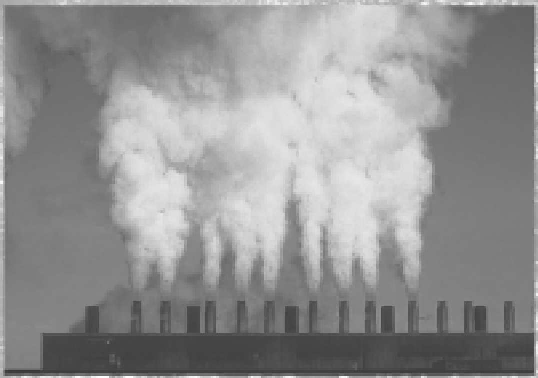


Aura is designed to answer questions about changes in our life-sustaining atmosphere:

1. Is the stratospheric ozone layer recovering?

2. What are the processes controlling air quality?

3. How is the Earth's climate changing?



EARTH SCIENCE ENTERPRISE

NP-2004-4-631-GSFC