NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Aura Press Kit

Dedicated to The Health of the Earth's Atmosphere

JUNE 2004

A Mission to Understand and Protect the Air We Breathe

Contacts

Gretchen Cook-Anderson NASA Headquarters gcookand@mail.hq.nasa.gov	Policy/Program Office	(202) 358-0836
Lynn Chandler Goddard Space Flight Center lynn.chandler-1@nasa.gov	EOS Program Office Aura Project	(301) 286-2806
Alan Buis Jet Propulsion Laboratory alan.d.buis@jpl.nasa.gov	TES & MLS Instruments	(818) 354-0474
Bruce Buckingham Kennedy Space Center Bruce.Buckingham-1@nasa.gov	Launch Operations	(321) 867-2468

Contents

Gretchen Cook-Anderson
Headquarters, Washington
(Phone: 202/358-0836)

Lynn Chandler/Krishna Ramanujan
Goddard Space Flight Center, Greenbelt, Md.
(Phone: 301/206-2806 or 301/286-2806)

May 17, 2004

RELEASE: 04-158

NASA PLANS TO PUT AN AURA AROUND THE EARTH

On July 8, NASA will launch Aura, a next generation Earth-observing satellite. Aura will supply the best information yet about the health of Earth's atmosphere.

Aura will help scientists understand how atmospheric composition affects and responds to Earth's changing climate. The satellite will help reveal the processes that connect local and global air quality. It will also track the extent Earth's protective ozone layer is recovering.

Aura will carry four instruments each designed to survey different aspects of Earth's atmosphere. The instruments will provide an unprecedented and complete picture of the composition of the atmosphere. Aura will survey the atmosphere from the troposphere, where mankind lives, through the stratosphere, where the ozone layer resides and protects life on Earth.

Aura's space-based view of the atmosphere and its chemistry will complete the first series of NASA's Earth Observing System satellites. The other satellites are, Terra, which monitors land, and Aqua, which observes Earth's water cycle.

"Gaining this global view of Earth will certainly reap new scientific discoveries that will serve as essential stepping stones to our further exploration of the Moon, Mars and beyond, the basis of the Vision for Space Exploration," NASA Administrator Sean O'Keefe said.

Aura will help answer key scientific questions, including whether the ozone layer is recovering. Aura data may prove useful determining the effectiveness of international agreements, which banned ozone-depleting chemicals like chlorofluorocarbons (CFCs).

- more -

Aura will accurately detect global levels of CFCs, and their byproducts, chlorine and bromine, which destroy ozone. Aura will also track the sources and processes controlling global and regional air quality. It will help distinguish between natural and human-caused sources of these gases. When ozone exists in the troposphere, it acts as an air pollutant. Tropospheric ozone is linked to high levels of precursors such as nitrogen dioxide, carbon monoxide and volatile hydrocarbons. Aura will help scientists follow the sources of tropospheric ozone and its precursors.

"Aura, the first comprehensive laboratory in space to help us better understand the chemistry and composition of the Earth's atmosphere, is fundamentally a mission to understand and protect the very air we breathe, " said NASA Associate Administrator for Earth Science Dr. Ghassem Asrar. "It is also a perfect complement to our other Earth Observing System satellites that, together, will aid our nation and our neighbors by determining the extent, causes, and regional consequences of global change," he said.

As the composition of Earth's atmosphere changes, so does its ability to absorb, reflect and retain solar energy. Greenhouse gases, including water vapor, trap heat in the atmosphere. Airborne aerosols from human and natural sources absorb or reflect solar energy based on color, shape, size, and substance. The impact of aerosols, tropospheric ozone and upper tropospheric water vapor on Earth's climate remains largely unquantified. Aura's ability to monitor these agents will help unravel some of their mystery.

Aura's four instruments, the High Resolution Dynamics Limb Sounder (HIRDLS); the Microwave Limb Sounder (MLS); the Ozone Monitoring Instrument (OMI); and the Tropospheric Emission Spectrometer (TES) will work together to provide measurements in the troposphere and stratosphere to help answer important climate questions.

HIRDLS was built by the United Kingdom and the United States. OMI was built by the Netherlands and Finland in collaboration with NASA. NASA's Jet Propulsion Laboratory in Pasadena, Calif., constructed TES and MLS. NASA's Goddard Space Flight Center, Greenbelt, Md., manages the Aura mission.

NASA's Earth Science Enterprise is dedicated to understanding the Earth as an integrated system and applying Earth System Science to improve prediction of climate, weather, and natural hazards using the unique vantage point of space.

For Aura information and images on the Internet, visit:

http://www.gsfc.nasa.gov/topstory/2004/0517aura.html

&

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

- end -

WHAT NASA WOULD LIKE YOU TO KNOW ABOUT THE AURA MISSION

NASA’s 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 with the first global view of the Earth's atmosphere, knowledge that will also enable exploration of worlds 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.

Media Services Information

NASA Television Transmission

NASA Television can be found on the satellite AMC 9 Transponder 9C, 85 degrees west longitude, vertical polarization downlink frequency - 3880 MHz, Audio is at 6.8 MHz.
On launch day, television coverage will begin at 1:30 a.m. PDT and continue through spacecraft separation. The schedule for television transmissions for Aura will be available on the NASA Television homepage at http://www.nasa.gov/ntv

Audio
Audio only will be available on the V circuits that may be reached by dialing 321-867-1220, 1240, 1260, 7135, 4003, 4920.

Webcasting: KSC will host a live webcast from VAFB on L-2 focusing on the mission and again on L-1, focusing on launch readiness. The live webcast will be available at http://www.ksc.nasa.gov

There will also be a live webcast of the launch hosted by e:SPI at GSFC. The webcast will take place from VAFB between L-1hr and L+2hr, to a worldwide audience. A continuous chat session will be ongoing to the public and to secondary schools in the USA. To test your system readiness and to view the webcast, log-in earlier at
http://spioffice.gsfc.nasa.gov/aura

Briefings
The prelaunch news conference will be held in the main conference room of the NASA Vandenberg Resident Office, Building 840, Vandenberg Air Force Base, Calif., July 6 at 12 noon PDT. Additional information will be sent in a Note to Editors.

Launch Media Credentials
U.S. news media desiring accreditation for the launch of Aura should fax their request on news organization letterhead to:

NASA Vandenberg Resident Office
Vandenberg Air Force Base, CA
Attention: Bruce Buckingham
FAX: 805/605-3380

Foreign news media desiring accreditation should fax their **request at least 10 days prior** to launch to:

30th Space Wing Public Affairs Office
Vandenberg Air Force Base, CA
FAX: 805/606-8303

For further information on launch accreditation call the Kennedy Space Center News Center at 321/867-2468. Beginning July 6 media may call the NASA Aura News Center at Vandenberg Air Force Base 805/605-3051.

News Center/Status Reports
The Aura News Center at the NASA Vandenberg Resident Office will open July 6 (L-2) and may be reached at (805) 605-3051. Recorded status reports will be available beginning L-2 at (805) 734-2693.

Internet Information
More information on the Aura mission, including an electronic copy of this press kit, press releases, fact sheets, status reports and images, can be found at:
http://aura.nasa.gov

Aura Quick Facts

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: 6,542 pounds (2.967 kg)

Power: 4.6 kilowatts of electrical power from its solar array

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, Calif.

Expendable Launch Vehicle: Boeing's Delta 7920-10L

Launch Date & Time: July 8 at 3:01 a.m. PDT (6:01 a.m. EDT) (3-min launch window)

Aura spacecraft separation: Launch + 64 minutes & 5 seconds

First Acquisition of Aura Signal: Launch + 25 hours

Beginning of Science Operations: Launch + 90 days

Cost: $785 million for Aura development costs, including launch vehicle

Spacecraft Builder/Integrator: Northrop Grumman, Redondo Beach, Calif., under contract with Goddard Space Flight Center

Launch Vehicle/Operations: NASA's Kennedy Space Center, Fla. @ VAFB

Mission Management: Goddard Space Flight Center, Greenbelt, Md.

Aura
Dedicated to the Health of the Earth's Atmosphere

Fact Sheet

Why Study Earth's Ozone, Air Quality and Climate?

So we can understand and protect the air we breathe. The Earth's upper atmospheric ozone layer protects all life. Between 1980 and 2000, protective ozone in the stratosphere decreased 3% globally. Depletion of the ozone layer allows more ultraviolet radiation to reach the surface, which is harmful to living things. The Montreal Protocol, an international agreement, banned the use of ozone destroying chemicals and the rate of ozone depletion seems to have slowed.

The Earth's air quality is fundamental to public health and ecosystems. The atmosphere has no political boundaries; air pollution moves great distances across oceans and continents. The air we breathe today was breathed by somebody in another region yesterday. The quality of air has degraded over certain parts of the world and has become a health issue.

The Earth's climate is affected by changes in atmospheric composition. It is undeniable that human activity is beginning to alter the climate. The global rise in surface temperatures since the 1950s is correlated with the increase in greenhouse gases, especially carbon dioxide.

The Aura Mission

NASA's Earth Observing System (EOS) Aura satellite will study the Earth's ozone, air quality and climate. The 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. Aura will explore the atmosphere's natural variability and its response to human activity so that we can better predict changes in the Earth system.

Measurements from Aura's four primary instruments will provide accurate data for predictive models and useful information for local and national agency decision support systems. Aura is the third in a series of large Earth observing platforms to be flown by NASA with international contributions.

Key Science Questions

The measurements from Aura's four instruments will help to answer questions about changes in our life-sustaining atmosphere such as:

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

Aura and the A-Train

By 2006, Aura will be a member of the “A-Train,” a constellation of six Earth-observing satellites flying in a formation, including: Aqua, CloudSat, CALIPSO, and the Orbiting Carbon Observatory (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, combining the data from these complementary satellite observations will enable scientists to unravel the complex interactions among climate, air quality and ozone depletion.

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 studies Earth system science, born of the recognition that the Earth’s land surface, oceans, atmosphere, ice cover, and life are dynamic and highly interactive.

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, an interagency effort to understand the processes and patterns of global change.

Aura Mission web site: http://aura.gsfc.nasa.gov/
Earth Science Enterprise web site: www.earth.nasa.gov.

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.

<u>HIRDLS Contributions to Understanding Stratospheric Ozone</u>
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 CFCs, NO2, and HNO3, gases that play a role in stratospheric ozone depletion. Although international agreements have banned CFC 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 improve our ability assess the transport of air from the troposphere into the stratosphere.

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

<u>HIRDLS Contributions to Understanding Climate Change</u>
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 the Upper Atmosphere Research Satellite (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.

<u>MLS Contributions to Understanding Stratospheric Ozone</u>
Aura's MLS will continue the ClO measurements and provide first time global HCl measurements. These measurements will inform us about the rate at which stratospheric chlorine is destroying the ozone. MLS will also provide 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 will measure vertical profiles bromine monoxide (BrO) for the first time, a powerful ozone-destroying radical. BrO has both natural and man-made sources.

MLS measurements of ClO and HCl will be extremely helpful to scientists studying 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.

<u>MLS Contributions to Understanding Air Quality</u>
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.

<u>MLS Contributions to Understanding Climate Change</u>
A critical unanswered question in understanding climate is what controls the abundance of water vapor in the upper troposphere and lower stratosphere (UTLS). MLS's measurements of UTLS water vapor and temperature as well as upper troposphere ice content, will be used to reduce the uncertainty in this critical climate forcing. MLS also measures greenhouse gases such as ozone and N2O in the upper troposphere, and water measurements

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 than the Total Ozone Mapping Spectrometer (TOMS) instruments, which preceded Aura. OMI 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.

OMI Contributions to Understanding Air Quality
OMI will also measure the atmospheric column of radicals such as nitrogen dioxide (NO2) 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 spatial 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.

<u>TES Contributions to Understanding Stratospheric Ozone</u>
TES limb measurements extend from the Earth's surface to the middle stratosphere. As a result, TES's high resolution spectra will allow scientists to make measurements of some additional stratospheric constituents that compliment the HIRDLS and MLS measurements.

<u>TES Contributions to Understanding Air Quality</u>
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 CH4, HNO3 and CO. TES is unique because its the first space-based instrument designed with tropospheric profiling in mind. TES data will be used to improve regional ozone pollution models.

<u>TES Contributions to Understanding Climate Change</u>
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 Science Objectives

The Three 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 (O2) by solar UV radiation. Individual oxygen atoms can combine with O2 molecules to form ozone molecules (O3). 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 lower 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 (N2O) 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 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 showed the synoptic (continental) scale of this depletion and 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 ClONO2 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 (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. Consequently, 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 agricultural 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.

Long Range Pollution Transport
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 even from one continent to another.

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. By having this capability on OMI, we will be able to extend the previous TOMS record to enable us to look at longer-term trends, as well as interannual variability through the end of this decade.

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 affect 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.

<u>What will Aura do?</u>
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 increases in the greenhouse effect and 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 any in 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.

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 (CO2) also affects the climate of the upper atmosphere. Where the atmosphere is thin, increasing CO2 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 CO2. 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.

<u>What will Aura do?</u>
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.

Mission Timeline

Main Engine Start	L+0
Solid Rocket Motor Jettison (6 of 9)	L+ 1 min 27 secs
Solid Rocket Motor Jettison (3 of 9)	L+ 2 min 11.5 secs
Main Engine Cutoff	L+ 4 min 23.5 secs
2nd Stage Ignition	L+ 4 min 37 secs
Fairing Jettison	L+ 4 min 41 secs
Second Engine Cutoff I	L+ 11 min 16.1 secs
2nd Stage Restart	L+ 58 min 10 secs
Second Engine Cutoff II	L+ 58 min 26.1 secs
Spacecraft Separation	L+ 64 min 5 secs
Beginning of Science Operations	L+ 90 days
Start Receiving Science Results	L+ 1 year

Aura Project Management Personnel

Phil DeCola
Dr. DeCola is Program Scientist for the Atmospheric Composition Focus Area in the NASA Earth Science Enterprise (ESE) and is Program Scientist for the Aura Mission. His scientific training and research is in the areas of molecular spectroscopy and condensed phase energy transfer. He has authored a number of publications in the area of nonlinear spectroscopy and its application to solid-state energy transfer. His involvement in Earth Science began through application of his scientific expertise to remote sensing of the Earth's atmosphere.

Dr. DeCola serves as the co-Chair of the U.S. Government's Climate Change Science Program Sub-group on Atmospheric Composition. He has served as Program Scientist for the Earth System Science Pathfinder Program (ESSP), a science-driven program intended to identify and develop low-cost, quick turnaround space-borne missions addressing high priority Earth system science objectives. He is also Program Scientist for a number of other atmospheric composition focused space missions, including the Orbiting Carbon Observatory (OCO), a mission designed to precisely measure global distributions of carbon dioxide in order to greatly reduce uncertainty in the global carbon cycle. (OCO is scheduled to be launched in 2007 and to join Aura in the A-Train formation.)

Dr. DeCola has received the Terra Award in Earth Science, the NASA Exceptional Performance Award and a number of other awards for his leadership of Atmospheric Composition research within NASA. He received both his Bachelor of Arts in Chemistry and his Ph.D. in Chemical Physics from the University of Pennsylvania in 1984 and 1990, respectively, and was awarded a National Academy of Sciences postdoctoral fellowship in 1991. He greatly enjoys his involvement in science education and outreach at the Pre-K through Graduate School levels, especially at the schools of his two children Frankie (6) and Nina (3).

Rick Pickering
Rick Pickering, the Aura Project Manager since March 2002, is an Aerospace Engineer at NASA's Goddard Space Flight Center, where he has worked since April 1989. Since coming to NASA, he has served in positions of increasing responsibility on the EOS Terra, Landsat 7, Earth Observing-1, Vegetation Canopy Lidar (VCL), and EOS Aqua missions. Rick graduated from the U.S Naval Academy in 1980 and entered the Marine Corps, where he served as an Aircraft Maintenance Officer. After serving five years in the Marines, he left active duty to take a position with ARINC Research Corporation. He entered federal service in 1987 with the Naval Air Systems Command, where he served as a Systems Engineer on the E-2C and C-2A programs. Rick retired from the Marine Corps Reserve in March 2003. He and his wife, Sharon, have been blessed with three children: Stacey, Kim, and Scott.

John Loiacono

John Loiacono has been the Deputy Project Manager for the Aura mission since the spring 2000. Prior to this, he was the Aura Instrument Systems Manager from 1998 to summer 2001, and the Aura OMI instrument manager from spring 1999 to summer 2000. John started at NASA's Goddard Space Flight Center (GSFC) in 1984 as an electronic engineer. He moved into the GSFC management organization, called the Flight Projects and Program Management Directorate, in 1998 when he joined the Aura team. As an engineer and manager, his work has centered on the design, development and launch of science instrumentation used in measuring the composition of physical processes and phenomena in the universe. Some of the science instruments and satellites in his repertoire include the following: the Galileo Probe Neutral Gas Spectrometer - the first to measure the atmospheric composition of Jupiter' s atmosphere; the Total Ozone Monitoring Spectrometer (TOMS) - used to measure trends in ozone loss and recovery; the Hubble Space Telescope's Imaging Spectrometer (HST/STIS) - measures the composition of other galaxies and the discovery of black holes; and the Advanced Land Imager on Earth Observer-1 that produces very high spectral resolution images of earth from space.

Mr. Loiacono received his Bachelor's degree in Electrical Engineering from The Catholic University of America (1980-84), attended University of Maryland for Masters in Electrical Engineering (1986-88) and George Washington University for Masters in Engineering Management (1992). Mr. Loiacono was selected into the very first technical class of the NASA/GSFC Program Management Development Emprise (PMDE) program in 1990. He was awarded NASA's Exceptional Achievement Medal in recognition of his technical leadership and engineering excellence in the design, development and launch of the Meteor-3/TOMS mission, and the Civil Service Excellence Award for his role in the development of the HST/STIS instrument.

Mark Schoeberl

Dr. Mark Schoeberl, the Aura Project Scientist, is an atmospheric scientist who specializes in stratospheric processes including wave dynamics, ozone depletion and trace gas transport. He has over 155 refereed publications and over 4200 citations in atmospheric science journals. Since the early 1980’s he has worked at NASA Goddard Space Flight Center, and is currently the Chief Scientist for the Earth Sciences Directorate and the Aura Project Scientist.

Dr. Schoeberl is past President of the Atmospheric Sciences Section of the American Geophysical Union (AGU). He is the former Upper Atmospheric Research Satellite (UARS) Project Scientist. He was the Co-Project Scientist for the airborne VOTE/TOTE mission (1996) and was Co-Project Scientist for the airborne SOLVE I and II missions (2000). He is also a past member of the National Academy’s Board of Atmospheric Sciences.

Dr. Schoeberl is a Fellow of the American Geophysical Union (1996), the American Association for the Advancement of Science (1996), and the American Meteorological Society (1996). He was awarded Goddard’s William Nordberg Memorial Award for Earth Sciences (1998), NASA's Exceptional Scientific Achievement Medal (1991), NASA’s Outstanding

Leadership Medal (1996) and Distinguished Service Award (2000), the latter being NASA's highest award of this type. He is the AMS Sigma Xi Lecturer for 2005. Dr. Schoeberl grew up in Iowa, and received his Ph.D. in Physics at the University of Illinois in 1976.

Mike Tanner

Mike Tanner is the Aura Program Executive from the Office of Earth Science at NASA Headquarters. Mike is directly responsible for providing overall guidance, direction and oversight for the development of the Aura project. As Program Executive, Mike provides policy and programmatic guidance, responds to inquiries and serves as the point of contact for domestic and international partnering organizations. Serves as a strategic mission architect for the Enterprise working with the science, operational and applications organizations to develop strategies and policies designed to maximize the integration of the requirements and implementation efforts. Analyses proposed missions and future systems and justify the scope, content, status and direction of the program to NASA management, Office of Management, Congress, Office of Science and Technology Policy and the NASA Centers. Mike received a Bachelor of Science degree from the University of Notre Dame and a Masters Degree in Research and Development Engineering Management. Current memberships include AIAA, National Space Foundation, and the United States Soccer Federation. In his spare time Mike is a nationally certified soccer referee participating in the Olympic Development Program. Mike and his wife Cindy live in Silver Spring, MD and have 2 teenage sons.

Dr. Pieternel Levelt

Pieternel Levelt is Principle Investigator of the OMI-instrument. Since 1993 she is a research scientist in the section Atmospheric Composition at the Royal Netherlands Meteorological Institute (KNMI). There she worked on chemical data-assimilation of ozone in two-dimensional and three-dimensional chemistry transport models. She was also member of the algorithm and validation subgroups of European satellite instruments GOME and Sciamachy. She was strongly involved in the validation program of both instruments. The results of her work at KNMI have been published in several articles and reports.

Pieternel studied Chemistry at the Free University of Amsterdam, and obtained her Master degree in 1987 on Physical Chemistry. She did her PhD at the Physics department of the Free University of Amsterdam and obtained her degree in 1992. Her PhD work consisted of the build of an XUV spectrometer based non-linear optical techniques and performing XUV-spectroscopy on small diatomic molecules, resulting in several publications.

In her spare time, Pieternel is involved in competitive triathlons (distance events containing a 1.5 km swim, a 40-km bicycle race, and a 10 km run), with a personal best of 2 hours 12 minutes, ranking her among the best in the Netherlands. However, most of her time is currently devoted to managing the OMI science team and enjoying her family.

Anne Douglass
Dr. Anne Douglass has been Deputy Project Scientist for the Aura mission since the fall of 1998. She is an atmospheric scientist at NASA's Goddard Space Flight Center, where she has worked since August 1981, with a research emphasis on stratospheric chemistry and transport. Her work emphasizes the development and analysis of predictive models and the quantitative evaluation of satellite, aircraft, and ground-based observations. She has also served as Deputy Project Scientist for the Upper Atmosphere Research Satellite since 1993, and shared in the 2002 William T. Pecora award for Understanding the Earth through Remote Sensing.

Dr. Douglass was featured in biographical profiles in the American Chemical Society educational magazine ChemMatters and in A Hand Up: Women Mentoring Women in Science, a publication of the Association for Women in Science. She is a Girl Scout leader and strives to bring opportunity to all girls. Anne majored in physics, and has a Bachelor of Arts degree from Trinity College where she was elected to Phi Beta Kappa. She has a master's degree from University of Minnesota, and a Ph.D. from Iowa State University. She is a fellow of the American Meteorological Society.

Ernest Hilsenrath
Ernest Hilsenrath is an Aura Deputy Project Scientist and is the U.S. Co-Principal Investigator for the Ozone Monitoring Instrument (OMI) flying on Aura. Mr. Hilsenrath has published over 50 papers on stratospheric science and instrumentation. He has conducted atmospheric chemistry experiments from the ground, aircraft, balloons, and the Space Shuttle while at Goddard Space Flight Center since 1964. As Principal Investigator, he flew a standard ozone instrument on the Shuttle eight times between 1989 and 1996 and experimented advanced ozone observing techniques on two Space Shuttle flights in 1997 and 2003.

He manages a laboratory for developing new instrumentation for atmospheric measurements and provides calibration services for all US and international ozone instruments ever flown using the backscatter technique such as TOMS and OMI. This research has lead to the development of the next generation ozone instrumentation to be flown on advanced meteorological satellites to be flown in the next decade.

Mr. Hilsenrath chairs and serves on several international committees and working groups which establishes and fosters international collaboration among the space fairing nations for atmospheric chemistry measurements.

PK Bhartia

Dr. Pawan K. (PK) Bhartia is the head of the Atmospheric Chemistry Branch at NASA Goddard Space Flight Center. He is also the Project Scientist of the Total Ozone Monitoring (TOMS) and the US Science Team Leader of the Ozone Monitoring Instrument (OMI). Dr. Bhartia is an internationally known expert in ultraviolet remote sensing of the Earth's atmosphere. He has written over 75 scientific papers in this area and has been recognized by NASA and international agencies for his contributions to this field. He was a leading member of the Ozone Processing Team (OPT) that was responsible for producing ozone products from the SBUV and TOMS instrument on NASA's Nimbus-7 satellite that was launched in September, 1978. Shortly after the discovery by two British scientists that the ozone layer over a station in Antarctica was rapidly thinning, Dr. Bhartia presented the first scientific paper that showed that the phenomena, which subsequently came to be known as the "ozone hole", covered almost the entire Antarctica continent. Maps of the ozone hole produced by TOMS generated world-wide attention and have played a key role in raising public awareness of the fragility of Earth's ozone layer that protects life on Earth from the harmful effects of Sun's ultraviolet rays. This led to international agreements to phase-out several offending chemicals, such as the CFCs, that were implicated in the formation of ozone hole and for general thinning of the ozone layer over rest of the world. Dr. Bhartia also pioneered the development of a technique to make precise estimates of the cancer-causing ultraviolet radiation that reaches the Earth's surface using satellite data.

As the OMI US Science Team Leader, Dr. Bhartia's principle goal is to use the OMI data to extend the unique TOMS record to monitor how changes in climate and chemistry of the atmosphere are affecting the ozone layer and the ultraviolet radiation reaching the surface. He is also collaborating with the international OMI science team in developing new products for applications in volcanology, climate, and air quality research.

Dr. Bhartia received his Ph.D. in Physics and MS in Computer Science degrees in 1977 from Purdue University, West Lafayette, Indiana. Dr. Bhartia joined NASA in Sept, 1991. Prior to that, he worked for various aerospace companies in both technical and managerial positions. He is the recipient of William Nordberg Medal and Exceptional Scientific Achievement award from NASA Goddard Space Flight Center for his contributions to satellite remote sensing of the atmosphere.

Reinhard Beer
Dr. Reinhard Beer has been the Principal Investigator for AURA Tropospheric Emission Spectrometer (TES) since its acceptance into the Earth Observing System (EOS) program in February 1989. He has studied the physics and chemistry of the atmospheres of the Earth and planets since joining the Jet Propulsion Laboratory in February 1963. His early work was focused on ground-based astronomical observations of planetary atmospheres, culminating in the discovery of carbon monoxide in the atmosphere of Jupiter and the first-ever detection of extraterrestrial deuterium (heavy hydrogen; also in Jupiter) for which he was awarded NASA's Exceptional Scientific Achievement medal in 1974. Since 1975 he has turned his attention to the remote sensing of the Earth's atmosphere from aircraft and from space. He was a co-investigator on four space shuttle flights of the ATMOS infrared spectrometer (aimed primarily

at the Earth's stratosphere and mesosphere)and has pioneered the spaceborne remote sensing of the Earth's troposphere. He is the author of a monograph on atmospheric remote sensing and a co-author of a text on laser remote sensing of the atmosphere. Reinhard's B.Sc. and Ph.D (both in physics) are from the University of Manchester (UK). He is a member of the Optical Society of America, the American Geophysical Union and the American Association for the Advancement of Science.

John Barnett
Dr. John Barnett is a Research Lecturer at Oxford University. He has worked on atmospheric satellite instruments since the early 1970s and has been joint PI of the HIRDLS instrument since its inception in 1989. He is interested in the temperature structure of the atmosphere and the way that wind motions move and mix chemical species in the upper troposphere and stratosphere. His wife works on the structure of viruses and his two daughters are far more interested in horses than science. He is a member of the Steam Boat Association of Great Britain and the Haflinger Club, having one of each form of transport. He received his M.A. from Cambridge University and his D.Phil. from Oxford University, and has also worked at the Jet Propulsion Laboratory, Berlin Free University, and the Massachusetts Institute of Technology.

Lucien Froidevaux
Dr. Lucien Froidevaux has been involved with satellite atmospheric remote sensing retrievals and data analysis since 1983, when he started working at NASA's Jet Propulsion Laboratory, managed by Caltech (Pasadena, CA). His early research (and doctoral thesis work) centered on photochemical models and the interpretation of measurements of atmospheric chemical species. He performed analyses of space shuttle-based observations by the Atmospheric Trace Molecule Spectroscopy (ATMOS) experiment and later joined JPL's microwave atmospheric science group. There, he has focused on satellite measurements by the Microwave Limb Sounder (MLS), first on the Upper Atmosphere Research Satellite (UARS) launched in 1991, and now on the Aura satellite.

Dr. Froidevaux's contributions on the MLS team have ranged from global real-time retrievals of atmospheric constituents to related stratospheric ozone and chlorine research. He has also been serving as Chair (with Anne Douglass of NASA Goddard Space Flight Center) of the Aura data validation activities. He is a Swiss citizen and resident of California, where he came to study after high school in Orsay, France.

He received a Bachelor of Science (Physics) from UCLA and a Masters and Ph.D. in Earth and Planetary Sciences from Caltech. He is a member of the American Geophysical Union. He stays busy at home, 'juggling' four children and a dog; he holds a black belt in karate and enjoys skiing, squash, travel, and photography.

John Gille
John Gille has been the US Principal Investigator for HIRDLS since its beginning in 1988. He is an Adjoint Professor at the University of Colorado as well as the founder of the Center for Limb Atmospheric Sounding (CLAS). He is also a Senior Scientist at the National Center for

Atmospheric Research. His research has been focused on developing limb-viewing satellite instruments to study the stratosphere and mesosphere, and analysis of the data they produce. He has lead the Limb Radiance Inversion Radiometer (LRIR) and the Limb Infrared Monitor of the Stratosphere (LIMS) experiments on the Nimbus program, and was a Collaborative Investigator with the Cryogenic Limb Array Etalon Spectrometer (CLAES) on the Upper Atmosphere Research Satellite (UARS). He has authored over a hundred papers on aspects of atmospheric science. John holds a B.S. from Yale College, a B.A. and M.A. from Cambridge University, all in physics. He received a Ph.D. in Geophysics from MIT. He is a fellow of the American Meteorological Society and the American Association for the Advancement of Science.

Joe W. Waters

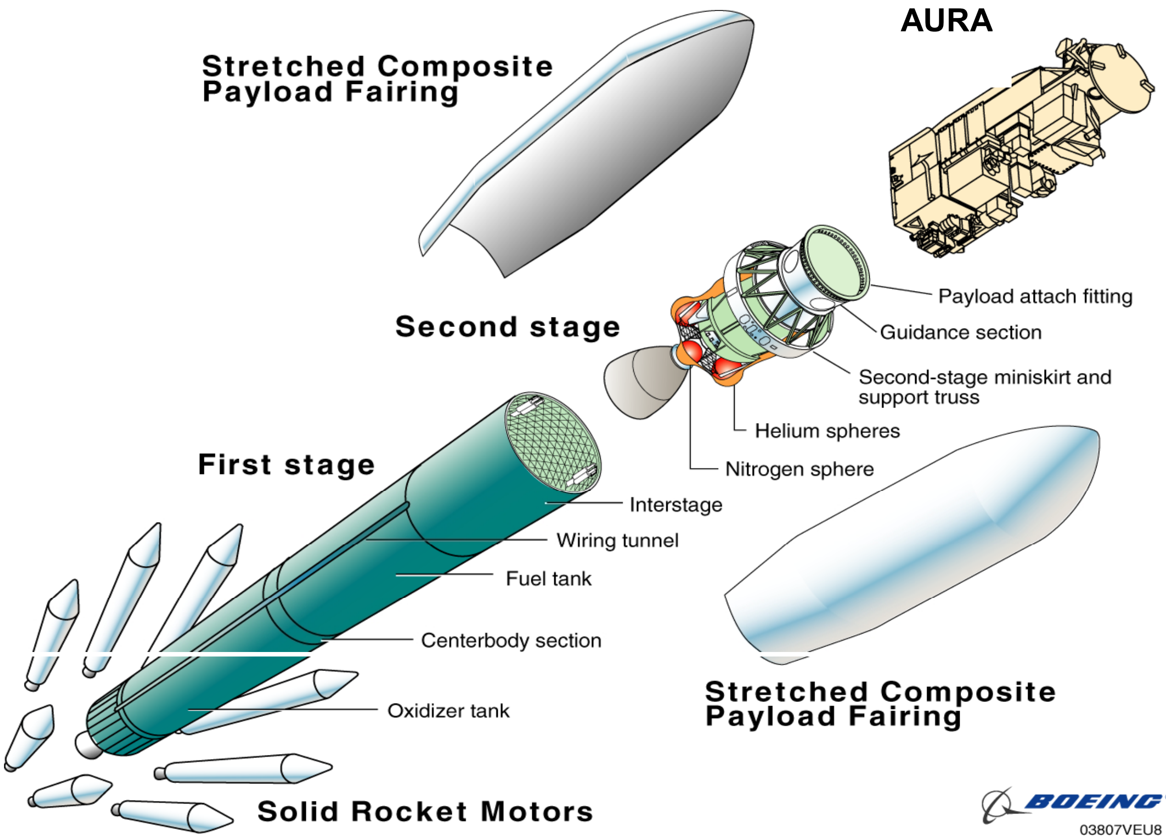
Dr. Joe Waters, the Microwave Limb Sounder Principal Investigator, is a scientist who specializes in the development and implementation of microwave experiments to provide important new information about Earth's atmosphere. He has over 145 refereed publications in his career, with more than 4000 citations. He is a Senior Research Scientist at the California Institute of Technology Jet Propulsion Laboratory (JPL), which he joined in 1973 to lead JPL's activities in microwave atmospheric science and instrument development for studying Earth's upper atmosphere. He currently leads groups in both science and engineering divisions at JPL.

Dr. Waters was awarded the NASA Exceptional Scientific Achievement Medal in 1985 for *'outstanding scientific achievements in the development and application of microwave and submillimeter remote sensing technology. These contributions have led to significant advances in our capability to measure the state of the Earth's atmosphere,'* and again in 1993 for *'outstanding scientific achievements in advancing knowledge of Earth's atmosphere through development of the NASA Upper Atmosphere Research Satellite Microwave Limb Sounder and analysis of its flight data.'* In 2001 *Science Watch* stated that he was the 16th most-cited author in geoscience for the decade 1991-2001.

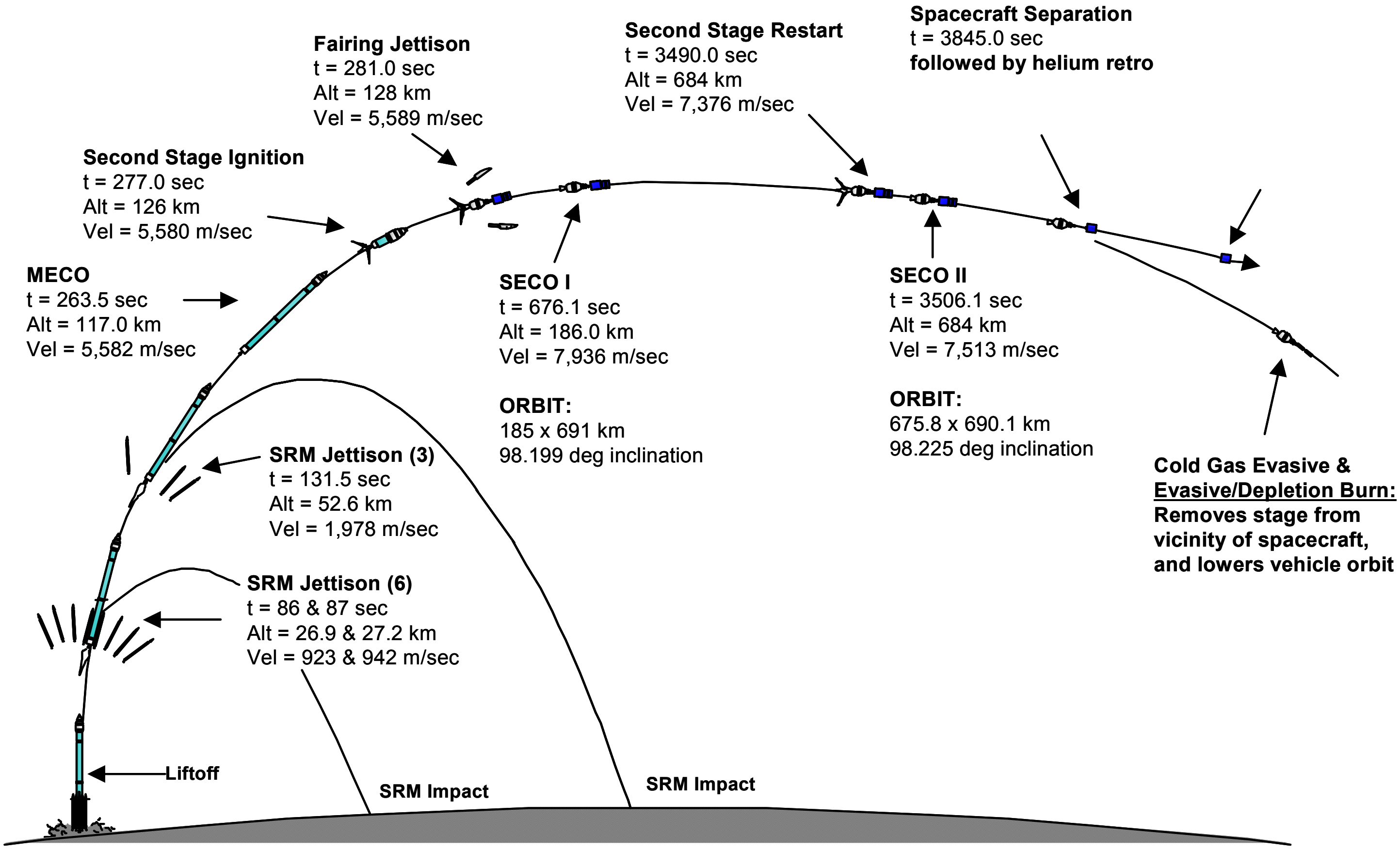
Waters received the B.S./M.S. and Ph.D. degrees from the Massachusetts Institute of Technology in 1967 and 1971, respectively. His Ph.D. thesis, under Prof. D.H. Staelin who pioneered microwave remote sensing, was on remote sensing of the stratosphere and mesosphere – from which his career evolved. While on the research staff at MIT he was responsible for validation of data from the first microwave temperature sounder in orbit. Dr. Waters grew up on a farm in Tennessee. His non-professional activities include hiking, backpacking, biking, guitar, gardening, travel, history and historical wooden ship models. He is married with two stepsons.

Delta Configuration

•Vehicle configuration: 7920-10L
•Launch site: SLC-2W at VAFB
•Launch date: 6/19/2004



Aura Boost Profile



Spacecraft Configuration