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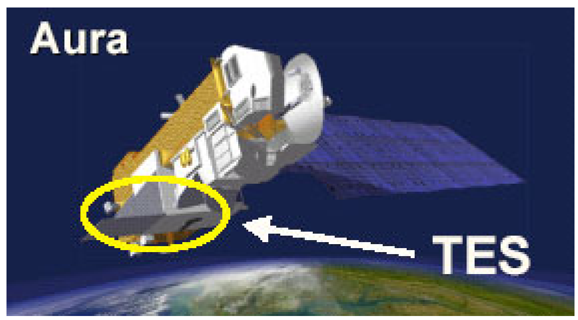
Earth Observing System Tropospheric Emission Spectrometer



The Earth Observing System Tropospheric Emission Spectrometer (TES) instrument on NASA's Aura spacecraft is a high-resolution, infrared-imaging Fourier transform spectrometer that observes the thermal emission (light energy, or radiance) of Earth's surface and troposphere (lower atmosphere) at spectral wavelengths from 3.2 to 15.4 micrometers. From these data, measurements of atmospheric composition, temperature and humidity can be derived at various heights, based on how the light energy is emitted and absorbed by molecules in the atmosphere. TES also measures local Earth surface temperatures, reflectance and emittance. Specific chemical species to be measured include ozone and other gas molecules that are involved in ozone formation and destruction, such as water vapor, carbon monoxide, methane, nitrogen dioxide and nitric acid. TES will measure, for the first time, the global distribution of these gases, furthering our understanding of long-term variations in their quantity, distribution and mixing.

The troposphere is the part of the atmosphere where we live. While only about 10 percent of Earth's ozone resides in the troposphere, it is nevertheless exceedingly important because of the multiple roles it plays. Ozone can be "good" or "bad." Near the surface it is a primary pollutant, and the source of photochemical smog that is becoming a worldwide problem. Large amounts of ozone near the ground also cause serious damage to trees and crops. Higher up, ozone is part of the chain of reactions that is the principal source of hydroxyl, the "detergent" molecule that removes atmospheric pollutants and species such as the halocarbon substitutes that are being manufactured by humans to help reduce the depletion of stratospheric ozone. In the upper troposphere, ozone is also a significant greenhouse gas.

The global distribution of tropospheric ozone is largely unknown, and the processes of ozone formation and destruction are exceedingly complex, making modeling of its distribution virtually impossible. Thus, a multi-year series of global surveys of tropospheric ozone itself and as many chemical precursors as possible is crucial.

TES observations will provide most of the information for a database of the three-dimensional local, regional and global distribution of gases important to tropospheric chemistry, interactions between the troposphere and biosphere, and exchanges between the troposphere and stratosphere. The data will be used to create and calibrate 3-D models of the present and future state of Earth's lower atmosphere. Other topics to be investigated include:

- global climate changes caused by increases in radiatively active gases;
- changes in the oxidizing power of the troposphere and the distribution of tropospheric ozone caused by urban and regional pollution sources, particularly carbon monoxide, nitrogen oxides, methane and other hydrocarbons. Analysis of TES data will allow us to better understand where tropospheric ozone comes from and how it interacts with other chemicals in the atmosphere, leading to improved regional ozone pollution models;
- Simultaneous measurements of nitrogen dioxide, carbon monoxide, ozone and water vapor to determine the global distribution of hydroxyl, an oxidant that "cleanses" the atmosphere;
- measurements of sulfur dioxide and nitrogen oxide as precursors to the strong acids dihydrogen, sulfur dioxide and nitric acid, which are the main contributors to acid depletion;
- sources and sinks (removal mechanisms) of chemical species important for generating tropospheric and stratospheric aerosols; and
- natural sources of trace gases, such as methane from organic decay, nitrogen oxides from lightning, and sulfur compounds from volcanoes (TES observations will also be used to study volcanic emissions to help mitigate hazards, determine the chemical state of magma, predict eruptions, and quantify the role of volcanoes as sources of atmospheric aerosols).

TES is one of four instruments onboard NASA's Aura spacecraft. In combination with the Microwave Limb Sounder (MLS), Ozone Monitoring Instrument (OMI) and High-Resolution Dynamics Limb Sounder (HIRDLS), this instrument suite represents the most advanced and accurate atmospheric chemistry laboratory ever deployed in space. The Aura instruments will operate collectively to provide very comprehensive information on our atmosphere, yielding much more valuable data together than if they were operated separately. TES limb measurements extend from Earth's surface to the middle stratosphere, and the TES spectral range overlaps the spectral range of HIRDLS. As a result, TES's high-resolution spectra will allow scientists to make measurements of some additional stratospheric constituents as well as improve HIRDLS measurements of species common to both instruments. TES has a higher resolution than OMI, but with less coverage.

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

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

TES Dual Observation Modes

Satellite observations of tropospheric chemicals using visible and infrared radiation are difficult to make due to the presence of clouds. To overcome this issue, TES was designed to observe both downward (in the nadir) and side-looking (across Earth's limb). This dual observation capability provides both low- and high-resolution measurements of the entire lower atmosphere, from the surface to the top of the stratosphere, offering the ability to measure essentially all radiatively active molecular species in Earth's lower atmosphere.

In the side-looking mode, TES provides much better measurements of the height of the gases but views a larger area, so clouds are much more of a problem. In this mode, TES can observe an area of approximately 26 kilometers by 41.8 kilometers (16.2 by 25.9 miles) with a high spectral resolution of 0.025 centimeters-1. Height resolution is 2.3 kilometers (1.4 miles), with coverage extending from the surface to 33 kilometers (0 to 21 miles).

The down-looking mode is best for looking at small areas (and finding gaps in the clouds) and for obtaining gas concentrations close to the surface. In that mode, TES will be able to observe an area of approximately 5.3 kilometers by 8.3 kilometers (3.3 by 5.2 miles) with a lower spectral resolution of 0.1 centimeters-1 and a spatial resolution of 0.53 by 5.3 kilometers (0.33 by 3.3 miles).

The routine TES operating procedure is to make continual sets of side-looking and down-looking observations, plus calibrations, on a one-day-on, one-day-off cycle. On "off" days, extensive calibrations and special product observations are made (e.g., volcanoes, biomass burning, pollution events). Acquisition of data is triggered when the Aura spacecraft crosses the southernmost point in its orbit (the southern apex). Thus, observations are made at the same latitudes during every orbit, and on every 16^{th} day identical locations are sampled. The observations cover a latitude range of plus or minus 82 degrees, with 72 observation sequences per orbit. Each observation sequence consists of two co-located ground targets, three side-looking tangents projected to the ground and two radiometric calibration measurements.

The TES Instrument

TES is a pointable instrument, with a two-axis gimbaled pointing mirror. Its field of view ranges from 45 degrees to –72 degrees along-track, plus or minus 45 degrees cross-track. It can make one scan every 4 or 16 seconds. It measures 140 by 130 by 135 centimeters (55 by 51 by 53 inches) stowed and 304 by 130 by 135 centimeters (120 by 51 by 53 inches) deployed, and has a mass of 385 kilograms (849 pounds). It operates on 334 watts of power. The data rate is 6.2 megabits per second peak, 4.9 megabits per second average. Two active Stirling cycle coolers, a heater and radiators provide thermal control. It operates in a thermal range of 0 to 30 degrees Celsius (0 to 86 degrees Fahrenheit). The instrument uses both the natural thermal emissions of Earth's surface and atmosphere and reflected sunlight to provide day-night coverage anywhere on the globe.

TES data will be distributed through the Distributed Active Archive Center at NASA's Langley Research Center, Hampton, Va. TES data will also be accessible from NASA's Earth Observing System Data Gateway.

NASA's Jet Propulsion Laboratory, Pasadena, Calif., developed, built, tested and will operate TES.

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

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