FactSheet

National Aeronautics and
Space Administration

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Lidar Atmospheric Sensing Experiment (LASE): Measuring Water Vapor, Aerosols, and Clouds

Moisture-related processes in the Earth's atmosphere have important human and economic impacts because of their relationship to weather and climate. Water vapor exists in the atmosphere only in small amounts, but it plays a big role in many important atmospheric processes. For example, water vapor is a fundamental part of the atmospheric energy budget, global water cycle, atmospheric chemistry, and transport processes of pollution. Scientists use the Lidar Atmospheric Sensing Experiment (LASE) system to obtain comprehensive, remote water vapor observations for a better understanding of its many roles in the atmosphere.

Since the 1960s, scientists have used lidars (light detection and ranging) to study the atmosphere. A lidar is an instrument that uses short pulses of laser light to detect particles or gases in the atmosphere, like a radar bounces radio waves off rain drops in clouds. A telescope collects and measures reflected laser radiation, like a radar dish collects the radar signal, leading to a profile of the atmosphere's structure along the path of the laser beam. Researchers can then determine the location, distribution, and nature of atmospheric particles and molecular species using an advanced lidar method called the Differential Absorption Lidar (DIAL) technique.

Different types of lidars measure different atmospheric properties. Scientists know that different molecules absorb light only at certain wavelengths. They can then tune laser pulses to different wavelengths to target the type of atmospheric molecule they want to study using the DIAL method. To measure water vapor, aerosols, and clouds, researchers use the LASE system. Scientists developed LASE as a prototype for a space-borne DIAL system. Since 1995 researchers have used LASE on six different major atmospheric field investigations. During the first two field experiments, LASE operated as an autonomous (controlled by a pilot) lidar aboard an ER-2 aircraft (fig. 1).

Fig. 1 An ER-2 uses LASE to take measurements of the atmoshere.

What is LASE?

LASE uses the DIAL technique to determine vertical profiles of water vapor in the lower atmosphere. It measures water vapor, clouds, and aerosols by comparing the absorption and scattering of different laser pulses on these atmospheric species. Laser beams are pointed out of the aircraft both upwards and downwards. Researchers operate LASE in the near infrared region of the electromagnetic spectrum and set one laser pulse to one wavelength, so water vapor will absorb the radiation, and another laser pulse to a slightly different wavelength to measure aerosols and clouds. LASE compares the two laser pulses as the atmosphere reflects them back to the telescope. Scientists use differences in the amount of laser light to determine the location and amount of water vapor, aerosols, and clouds in the atmosphere, essentially creating an atmospheric map of the area above and below the aircraft. LASE can measure water vapor distributions from the ground up to 20 kilometers. An example of simultaneous measurements of water vapor and aerosol distributions by LASE in the atmosphere is shown in fig. 2. These data were taken from the ER-2 aircraft as it flew back from near Bermuda to Wallops Island, Virginia, in July 1996.

Why measure water vapor?

Water vapor is an essential link in the water (hydrologic) cycle, which includes all forms of water (gas, liquid, ice, and snow). Also, water vapor is the main ingredient in cloud formation (which impacts precipitation) and in severe storm development. It is an invisible gas and acts as a buffer for the rise and fall of temperatures in the atmosphere. Once the temperature drops to the dew point, water vapor condenses, releasing heat, and the temperature rises again. Conversely, as temperature rises, water evaporates, taking up heat and cooling the atmosphere. Water vapor, a greenhouse gas, also influences the Earth’s radiation budget by absorbing outgoing longwave energy. In addition, water vapor channels energy into the atmosphere and is the main energy source for hurricane development.

Cloud and aerosol measurements

Simultaneous measurements of clouds and aerosols enhance water vapor investigations conducted using LASE, which can provide additional important information on atmospheric structure and movement. Scientists can also infer meteorological variables from these data, such as the depth of the mixed layer—the layer closest to the surface where most of the pollution is trapped and where many clouds form. Measurement of the distribution of clouds is important because clouds play a major role in meteorology, rainfall, and the atmospheric radiation balance.

Future LASE missions

NASA Langley scientists will participate in a Department of Energy (DOE) LASE field experiment on a NASA DC-8 aircraft during November and December of 2000 over the Southern Great Plains of the United States. The main objective of this field experiment is to compare the performance of a number of advanced water vapor sensors for measuring upper atmospheric humidity—measurements that are needed for studying the Earth's radiation budget and climate change.

For more LASE information, please contact:
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Or see the LASE Home Page at
http://asd-www.larc.nasa.gov/lase/ASDlase.html
for additional information.

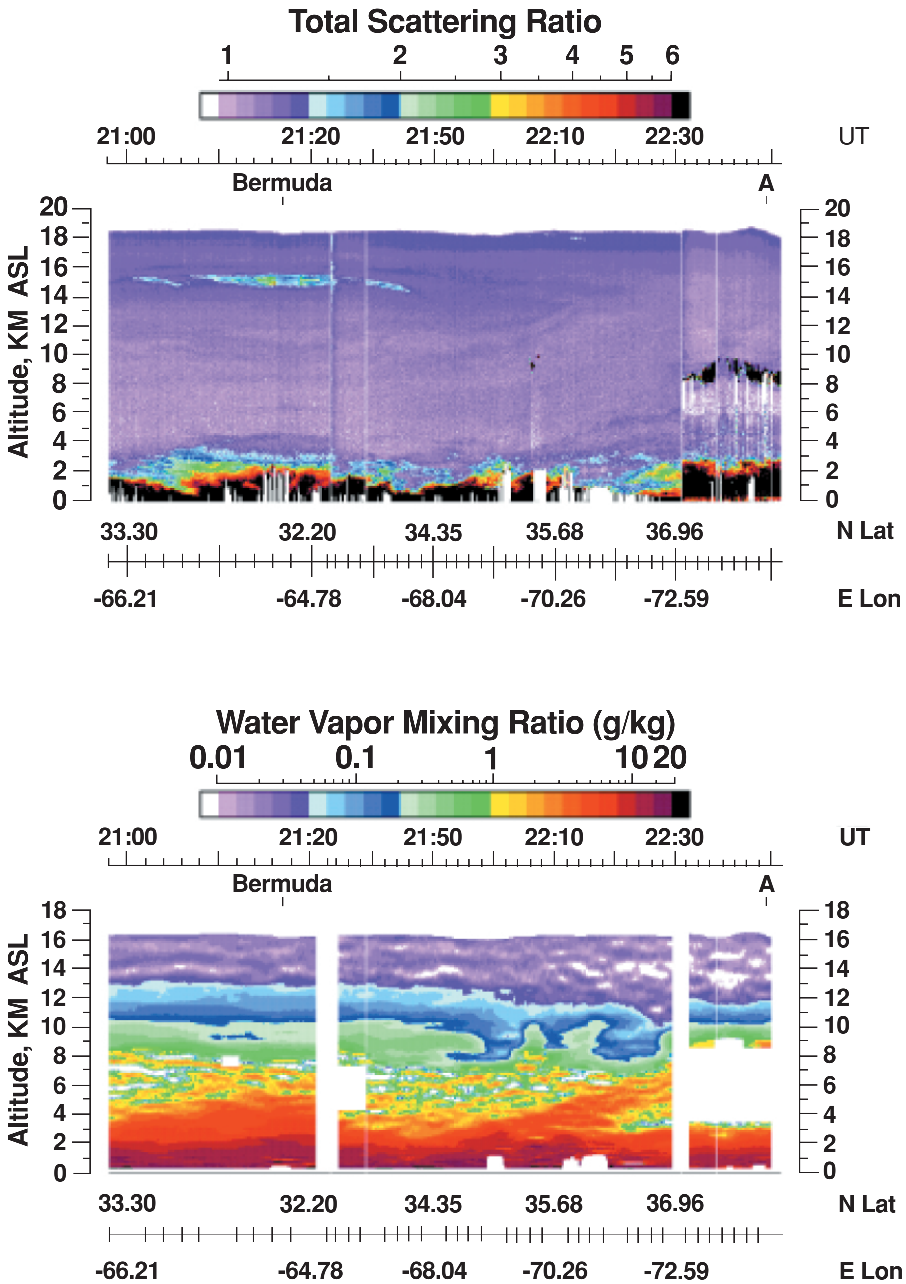

Fig. 2 Simultaneous measurements of aerosols (top panel) and water vapor by LASE on-board the ER-2 aircraft that flew from near Bermuda to Wallops, VA during the TARFOX (Tropospheric Aerosol Radiative Forcing Observational Experiment). The horizontal scales indicate the geographical coordinate of the measurement (at the Universal Time, UT) and the vertical scale indicates the vertical location. The color scale from pink (light detection) to black (heavy detection) indicates the intensity of aerosol scattering and the concentration of water vapor in the atmosphere. White areas in the top image (aerosol scattering) indicate regions inaccessible to measurements due to the presence of clouds or a lack of data. White areas in the bottom image (water vapor mixing) indicate measurements were below instrument threshold or a lack of data. These data indicate the complex and wide ranging distributions of aerosols and water vapor in the atmosphere that are mostly invisible to the naked eye.