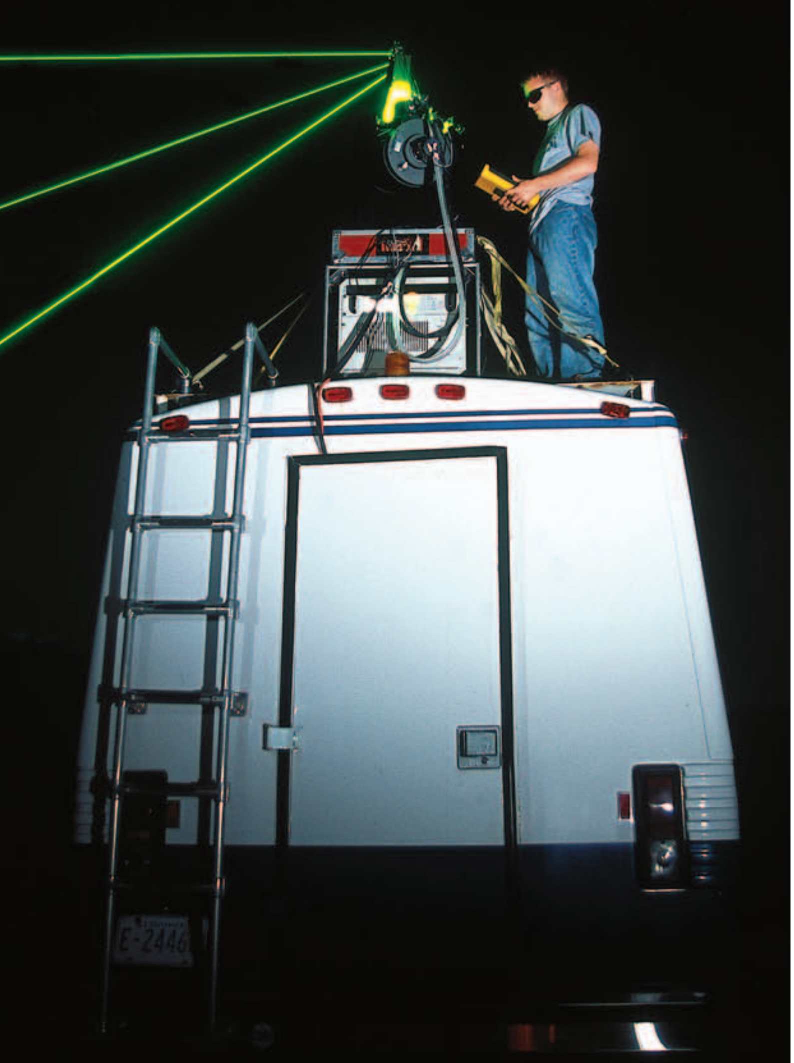
Seeing Air in a New Light With LiDAR

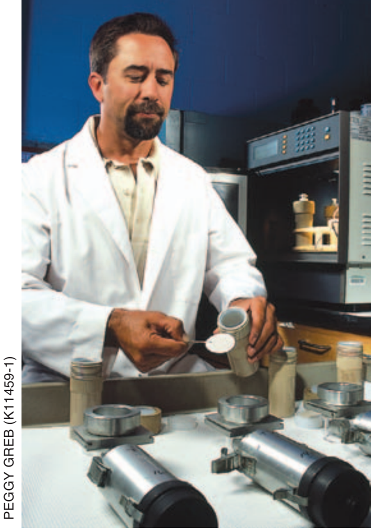


Micheal Cloos, a University of Iowa student, adjusts the LiDAR laser.

PEGGY GREB (K11458-1)

On a still, dark evening near Ames, Iowa, about 30 researchers and helpers mill about a large van parked in the middle of a vast cornfield. They gaze upward, at a tight, narrow, steady beam of hot, green light streaming from the vehicle. Hushed voices, carrying well through the summer air, rise in excited spurts as the beam—projected out into the star-filled sky—suddenly snaps westward, and then southward.

"I hope you're enjoying our light show," says Jerry Hatfield, director of ARS's National Soil Tilth Laboratory (NSTL) in Ames. A light show, yes. But what Hatfield and his colleagues are really doing is exhibiting the uses of LiDAR, a technology that's been around awhile but is now showing great promise for agriculture.



PEGGY GREB (K11459-1)

Technician Kenwood Scoggin prepares particulate-filter samples for microwave-assisted extraction as part of the liquid chromatography/mass spectrometer process to identify materials attached to particulates collected in rural Iowa.

Hatfield says LiDAR—for Light Detection and Ranging—"may revolutionize how we monitor the atmosphere around agricultural operations."

He explains that single-point monitors currently used to track tiny airborne particles force operators to assume that measurements represent the entire atmosphere. "LiDAR allows us to see just how accurate these samples are and how much the atmosphere in a given area is fluctuating. It gives us a multidimensional picture of what's going on."

Developed from laser studies during the 1960s, LiDAR has been used to look at clouds and plumes of gas and pollution, to detect stealthy submarines, to nab speeders, and to prepare topographic elements for land and ocean-floor maps.

Used In and Out of This World

The National Aeronautics and Space Administration (NASA), which in 1994 took LiDAR into space aboard the shuttle Discovery, describes the technology as being similar to radar. But instead of bouncing radio waves off its target, it uses short pulses of laser light to detect tiny particles, gases, or molecules in the atmosphere. Its tight, unbroken beam disperses very little as it moves away from its source. Computers analyze measured data from the reflected light, which scientists later analyze through display and tabulated formats.

"The technology works off of the principle of light-reflectance signature—that is, being able to identify the reflection that specific particles make when struck by laser light," says Hatfield. "It allows us to accurately determine the location, distribution, and nature of particles."

Hatfield says light emitted from LiDARs can vary in color, depending on the type of measurements being made. A complete, portable LiDAR costs between $100,000 and $200,000.

Hatfield says his laboratory doesn't own one but has worked out a collaborative agreement with the Los Alamos National Laboratory in New Mexico and the University of Iowa (UI) to use their instruments.

It's Versatile

"LiDAR can help us gain a profile of dust particles from mills and cotton gins—and even of particles that make up odor plumes that emanate from livestock facilities," says Hatfield.

Hatfield, NSTL soil scientist John Prueger, Los Alamos scientist Dan Cooper, and UI professor Bill Eichinger have incorporated LiDAR into ARS studies at various locations. The light exhibition in the cornfield was part of a soil moisture experiment series that ARS, NASA, the National Oceanic and Atmospheric Administration, and collaborating universities are conducting to evaluate how accurately remote sensors on satellites, aircraft, and land-based towers monitor ground-level moisture.

Hatfield, Prueger, and their team first used LiDAR in 1998 when they were asked by the U.S. Department of the Interior's Bureau of Reclamation to study the effect of saltcedar—an invasive and prolific shrub that removes large amounts of soil water while leaving behind soil-damaging salts—on western U.S. riverbanks.

Working along a section of the Rio Grande River south of Soccoro, New Mexico, the researchers compared LiDAR with two other methods for estimating water uptake by trees in riparian zones. They evaluated whether LiDAR could map the source of water loss in an area covered with vegetation.

"It allowed us to measure water loss with a resolution of 25 meters over an area of several square kilometers as accurately as by other methods," Prueger says. "This shows LiDAR can help us understand the dynamics of different land surfaces and the changes to them induced by management. It also supports the idea of using LiDAR to produce three-dimensional images of evaporation processes. An application of this is mapping plumes of water vapor above a riparian zone."

The scientists used a scanning LiDAR that helped produce maps showing the spatial distribution, as well as rates, of evaporation at regular intervals throughout the day. "The three-dimensional character of the data allowed us to detect water vapor anomalies," says Prueger.

Evaluating an Ill Wind

Hatfield, through an agreement with UI, is currently studying LiDAR's performance in evaluating dispersion dynamics around swine-production facilities. "Effects of agricultural management practices on air quality are ill defined," he says. "Many atmospheric components—such as ammonia, methane, nitrous oxide, carbon dioxide, particulates, bioaerosols, and herbicide vapors—must be considered. This is complicated by all the things that can affect an airborne particle, such as wind and terrain."

This study, says Hatfield, "can help us place instruments around livestock production units where they can effectively capture plume strength. Then, using mathematical techniques, we can estimate where specific compounds are coming from, how strong they are, and at what rate they're being emitted."

LiDAR can also be used to validate dispersion models for particulates such as dust, water vapor, ammonia, and livestock emission gases. "With it, we can create a data set for each of these particles," says Hatfield. "We can make precise atmospheric measurements that can be applied in many beneficial ways."—By **Luis Pons,** ARS.

This research is part of Air Quality, an ARS National Program (#203) described on the World Wide Web at www.nps.ars.usda.gov.

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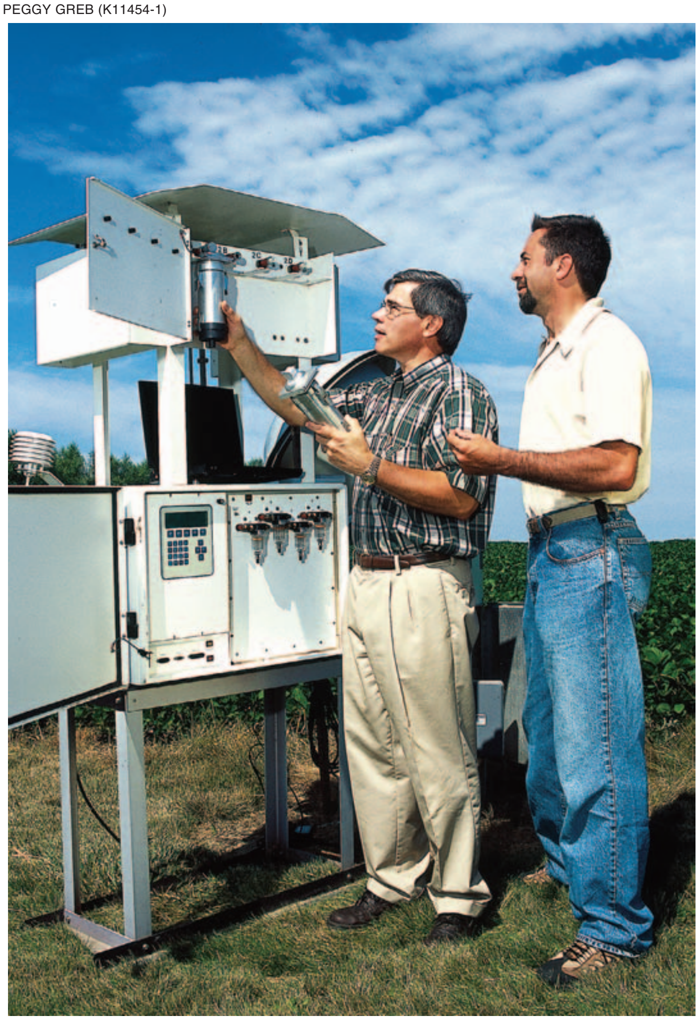

Laboratory director Jerry Hatfield and technician Kenwood Scoggin examine a particulate sampler during air quality studies in Iowa.