UCAR UNIVERSITY CORPORATION FOR ATMOSPHERIC RESEARCH

Improved Water Vapor Sensor Takes to the Skies

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BOULDER—By pairing a sleek new air sampler designed at the University Corporation for Atmospheric Research (UCAR) with a diode laser from SpectraSensors, Inc., researchers have hit on a technology that can capture highly accurate atmospheric water vapor data during routine commercial flights. The data will benefit researchers and forecasters, who need more frequent, accurate measurements at various altitudes worldwide to improve weather forecasts and monitor climate change.

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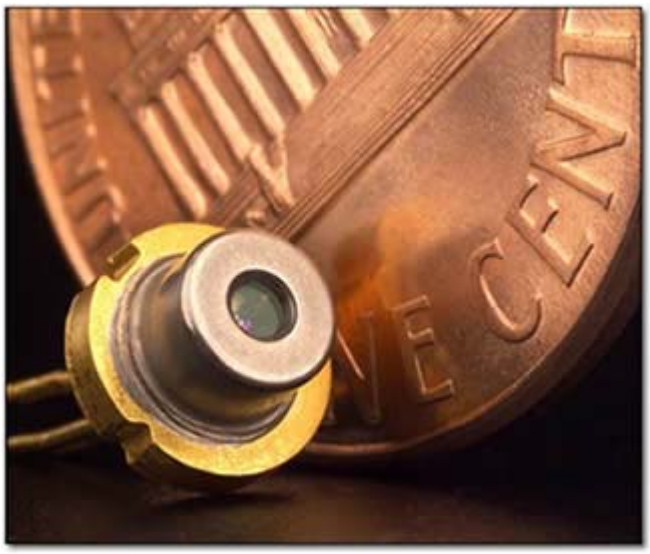

This tiny diode laser cell, paired with a UCAR-developed air sampler, provides an economical yet highly accurate alternative to weather balloons or satellites for collecting atmospheric water vapor data. (Photo courtesy SpectraSensors, Inc.)

This month UPS is flying the Water Vapor Sensing System II (WVSS II) on 25 of its Boeing (B-757) aircraft based in Louisville, Kentucky, to compare the data to measurements from weather balloons, satellites, and other instruments and to evaluate its performance aboard commercial planes.

Currently water vapor data is gathered by an older style of sensor using a thin-film capacitor. These sensors are launched on weather balloons every 12 hours from stations around the country. Satellites also gather water vapor data, but at low vertical resolution. The WVSS II aboard commercial flights will gather data more often, at higher vertical resolution, and at lower cost than satellites and balloons.

"Water vapor sounds boring," says recently retired UCAR scientist Rex Fleming, who designed the innovative air sampler, "but it's essential to almost everything that happens in the atmosphere." Better water vapor data from around the U.S. and the world can improve forecasts of thunderstorms, microbursts, turbulence, fog, ceiling visibility, rotating wakes from other aircraft, snow and ice storms, and year-round precipitation, he says.

Water vapor also plays an important role in small storms that develop quickly and wreak havoc with airline schedules and safety. The Federal Aviation Administration estimates these storms can cost the aviation industry more than $1 billion annually.

Improved aviation weather forecasts can make flying safer, allow airlines to expand the number and location of routes, provide alternate landing options, and save fuel. Over the long term, the new data can verify computer model projections of climate change, which indicate water vapor steadily increasing in Earth's atmosphere. As a greenhouse gas, water vapor is 10 times more

potent than carbon dioxide and its increase is a key factor in the rising global temperatures appearing in the models.

The aerodynamic design of the air sampler removes most ice crystals, particles, rain, and other distractions to improve the sensitivity of the measurement. (Photo courtesy Rex J. Fleming.)

The FAA certified the WVSS II for commercial aircraft flights last December. Preliminary results show the WVSS II data are highly consistent with the balloon data up to 35,000 feet. This month's tests should lead to verification of the sensing system for other uses by forecasters, air traffic controllers, and research scientists.

"In a typical year, more water in the form of vapor and clouds flows over the dry state of Arizona than flows down the Mississippi River," says Fleming. "Yet we have not had a sensing system to collect accurate water vapor data frequently enough to be really useful for forecasts." Commercial aircraft can fill a critical gap in atmospheric observations by gathering accurate data throughout the global atmosphere, he adds.

Mounted flush on the outside of the plane, Fleming's sampler channels air into the measurement cell housed in a casing the size of a cigar box just inside the aircraft shell. The sampler weeds out most ice crystals, particles, rain, and other distractions to improve the sensitivity of the measurement. The laser frequency itself sees only water vapor in the air flow.

Mounted flush on the side of 25 UPS (B-757) aircraft, the air sampler produces little in-flight drag. (Photo courtesy UPS.)

UPS has provided wind and temperature data to meteorologists from more than half its air fleet since 1994. In 1997, UPS added water vapor information, expressed as relative humidity, from a first-generation test sensor installed on 30 aircraft. The new second-generation sensors are expected to be far more accurate and reliable, especially at higher altitudes and colder temperatures.

Southwest Airlines will begin flying the system when further government funds are available. The German Weather Service is in the process of certifying the sensor, and Lufthansa will be installing four units on commercial flights later this year. New Zealand, Australia, and South Africa will collaborate with the German Weather Service on an initial purchase of ten units.

The FAA's Aviation Weather Research Program and NOAA's Office of Global Programs funded development of the WVSS II. The diode laser cell was designed by Randy May of SpectraSensors, the manufacturer of the product.
