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Langley's lasers study Earth's CO2

Scientists use tool to measure amounts of carbon dioxide in the atmosphere, in hopes of countering greenhouse gases

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Upendra Singh, associate director of NASA Langley Research Center's engineering directorate, shows off the B-200 research airplane that is outfitted with an airborne IPDA system. The system directs two pulses from a 2-micron, eye-safe laser from as high as 28,000 feet.

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Precise measurements of carbon dioxide in the atmosphere are key to figuring out how to counter the planet-warming greenhouse gas.

Now engineers at NASA Langley Research Center say they have cracked the world's first double-pulsed laser system that takes measurements of CO2 to a new level — a system that can extract data day or night, rain or shine, all over the planet from an airborne platform with the highest degree of accuracy.

"We have achieved all the things which we ever even dreamed about, so we are giddy," said Upendra Singh, associate director of the center's engineering directorate. "And we have so much quality data that I've never seen this kind of data, and I've been in LIDAR for 30 years."

LIDAR, or Light Detection and Ranging, uses pulses of light to make atmospheric measurements of a column of air and is the core of the new instrument.

Most researchers today use a passive remote sensing technique that measures CO2 absorption through sunlight, said Singh. This method precludes collecting data at night or at high latitudes such as the poles — regions that are crucial for CO2 research as glaciers and

See LASERS/Page 4

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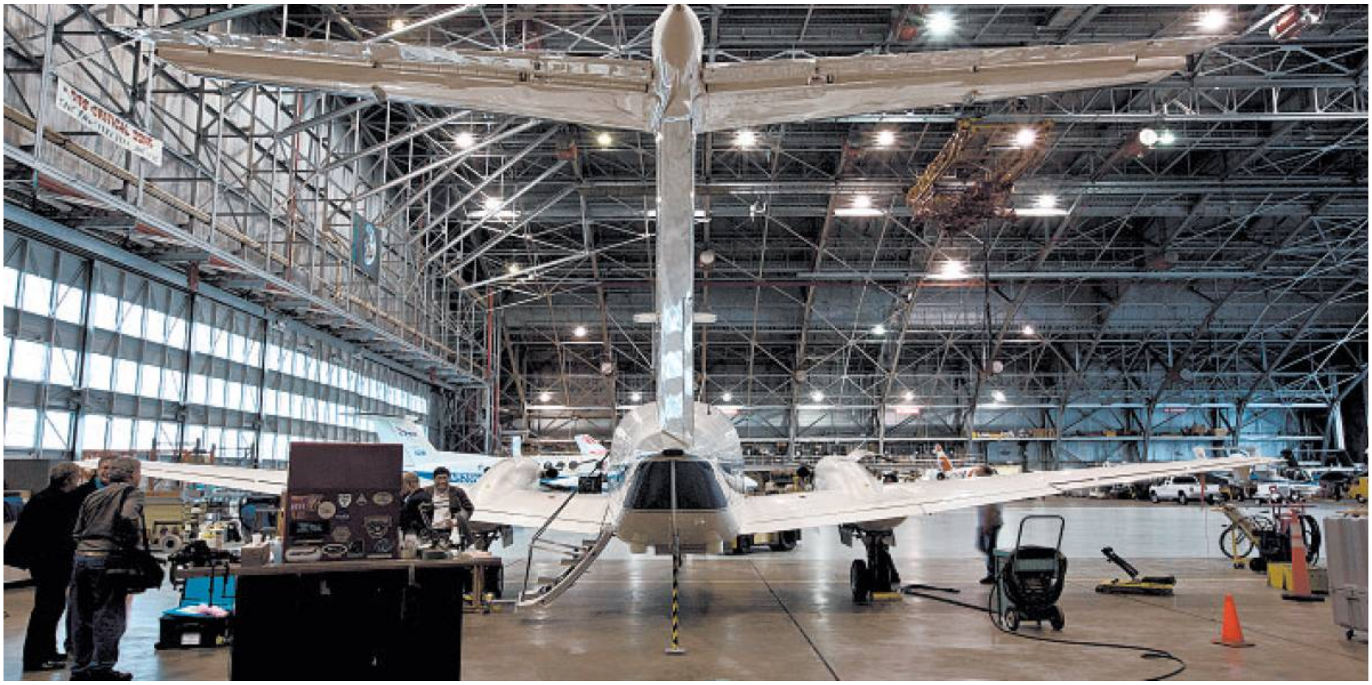
How does it work?

The IPDA system directs two pulses from a 2-micron, eye-safe laser from as high as 28,000 feet toward a range of weather conditions and terrains.

The pulses are rapid-fire at 10 per second. Once they hit their target, they bounce back to the plane. By measuring the infinitesimal difference in return between the two pulses, the engineers can determine the amount of carbon dioxide in the air column. Carbon dioxide absorbs laser light, so the higher the CO2 concentration, the smaller the return.



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NASA Langley plans to conduct flights with this aircraft throughout Virginia to study CO2 in the atmosphere. The airborne LIDAR project uses an eye-safe laser to measure carbon dioxide in the air, which scientists say is able to take measurements with the highest degree of accuracy.

Lasers

Continued from 1

ice sheets melt and release trapped carbon dioxide into the atmosphere.

But the team's new Integrated Path Differential Absorption (IPDA) LIDAR instrument eliminates those restrictions.

Engineer Tamer Refaat likens their system to taking a picture — carbon dioxide is the "scene" to be shot, LIDAR is the camera and the laser is the flash. Refaat is a senior research scientist at Old Dominion University Research Foundation in Norfolk, but has conducted modeling simulations and data analysis at NASA Langley for about 17 years.

LIDAR has long been used to detect different atmospheric molecules like water vapor and ozone, Singh said, and helped scientists study the hole in the ozone layer. Such data helped convince the U.S. Environmental Protection Agency to ban chlorofluorocarbons, or CFCs, 20 years ago.

"Now we have the same thing, or a similar thing, for measuring CO2," Singh said. "And hopefully that will come up with a solution for global warming."

How it works

For thousands of years, the amount of CO2 in the atmosphere has been fairly constant at 300 parts per million, he explained. But in the last 70 years or so, concentrations have jumped by a third to 400 ppm.

Working with a nearly $3 million grant from NASA's Earth Science Technology Office, project manager Jirong Yu assembled a team of fellow engineers in May 2012 to design and build their airborne IPDA instrument. Earlier this year, they bolted it inside a B-200 research airplane at the Hampton research center and began a series of test flights in late March and early April over Virginia, North Carolina and New Jersey.

The IPDA system, said Yu, directs two pulses from a 2-micron, eye-safe laser from as high as 28,000 feet toward a range of weather conditions and terrains — ocean, bay water, sand, snow, forests, soil, vegetation and urban environments, such as a power plant and highways.

The pulses are rapid-fire at 10 per second. Once they hit their target, they bounce back to the plane.

By measuring the infinitesimal difference in return between the two pulses, called the differential absorption LIDAR technique, the engineers can determine the amount of carbon dioxide in the air column. Carbon dioxide absorbs laser light, so the higher the CO2 concentration, the smaller the return.

It's a highly complicated system,

but the team nailed it on the first flight. They've made nine flights so far.

"We're very happy with it," said Yu. "This is a beautiful signal."

What's next?

Singh said engineers expect to spend the next several months analyzing the wealth of data they collected. While that data can be shared all over the world, the technology can't, he said, since the laser technology falls under the federal International Traffic in Arms Regulations.

Next up, the team plans to design and build an even more advanced triple-pulsed LIDAR system that can also measure water vapor, which researchers say is important for accuracy and to better understand where CO2 is generated and where it is absorbed.

Singh said they expect to fly that version in 2017, and hope NASA will choose it one day for "the big show" — an orbiting satellite that will take the global measure of CO2 day and night, from pole to pole, all around the planet.

That three-year project is being funded with a competitive $4.5 million grant from NASA's Instrument Incubator Program, managed by the Earth Science Technology Office.

"Once you understand what's happening, you can mitigate these things," said Singh. "And it will improve the quality of life of the people on Earth."

The team also includes lead instrument engineer Mulugeta Petros and software engineer Ruben Remus.

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