NASA to create first-ever space-based sodium lidar to study poorly understood mesosphere

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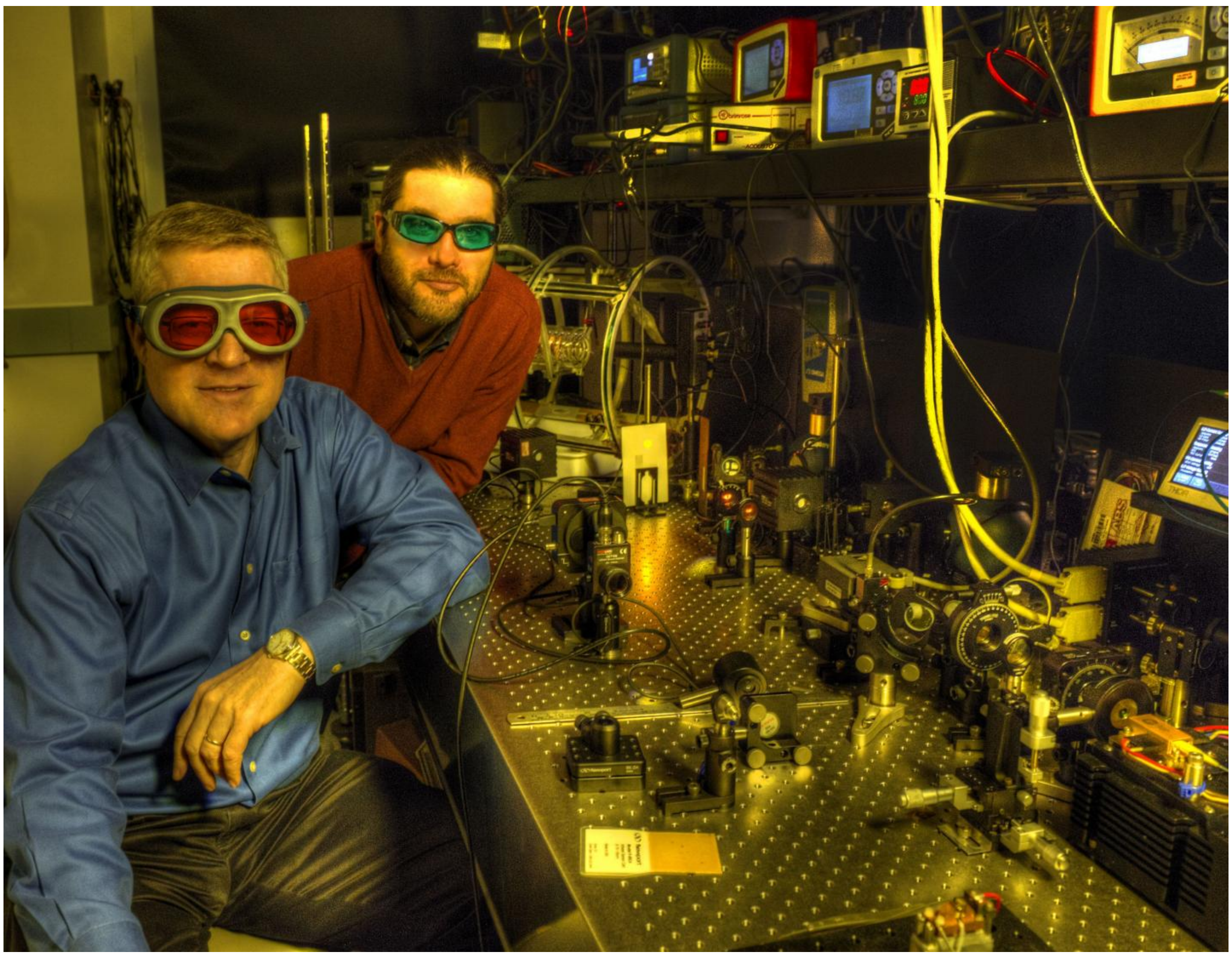


Mike Krainak (left) and Diego Janches recently won NASA follow-on funding to advance a spaceborne sodium lidar needed to probe Earth's poorly understood mesosphere. Credit: NASA/W. Hrybyk

A team of NASA scientists and engineers now believes it can leverage recent advances in a greenhouse-detecting instrument to build the world's first space-based sodium lidar to study Earth's poorly understood mesosphere.

Scientist Diego Janches and laser experts Mike Krainak and Tony Yu, all of whom work at NASA's Goddard Space Flight Center in Greenbelt, Maryland, are leading a research-and-development effort to further advance the sodium lidar, which the group plans to deploy on the International Space Station if it succeeds in proving its flightworthiness.

NASA's Center Innovation Fund and the Heliophysics Technology and Instrument Development for Science programs are now funding the instrument's maturation. However, the concept traces its heritage in part to NASA's past investments in promising lidar instruments, called Sounders, originally created to measure carbon dioxide and methane in Earth's atmosphere.

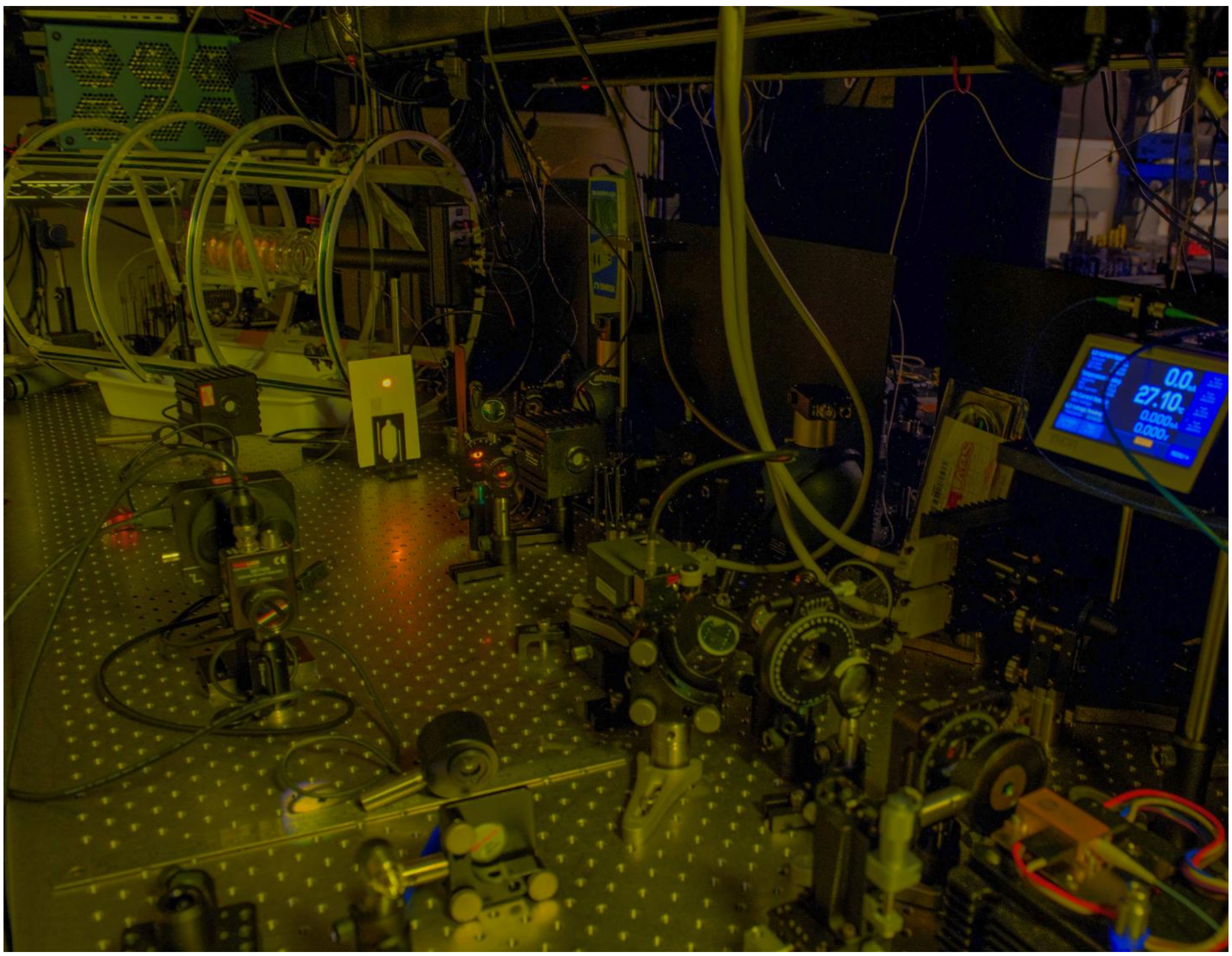
From its berth on the orbiting outpost, the instrument would illuminate the complex relationship between the chemistry and dynamics of the mesosphere that lies 40-100 miles above Earth's surface—the region where Earth's atmosphere meets the vacuum of space.

Given the progress the researchers have made with the Earth-observing sounding instruments, coupled with Goddard's legacy in laser technology, they are optimistic about the instrument's ultimate success.

The Big Leverage

"What we're doing is leveraging what we learned with the CO2 and Methane Sounders," Krainak said. Both instruments have demonstrated in multiple aircraft campaigns that they accurately measure greenhouse gases using lidar.

Lidar involves pulsing a laser light off Earth's surface. Like all atmospheric gases, carbon dioxide and methane absorb the light in narrow wavelength bands. By tuning the laser across those absorption lines, scientists can detect and then analyze the level of gases in that vertical path. The more gas along the light's path, the deeper the absorption lines.



With NASA technology-development funding, a Goddard team of scientists and engineers will advance a sodium lidar instrument for use in space. This image shows the laboratory breadboard. Credit: NASA/W. Hrybyk

"The same principle applies here," Janches said. "Instead of carbon dioxide and methane, we're detecting sodium because of what it can tell us about the small-scale dynamics occurring in the mesosphere."

Sodium—the sixth most abundant element in Earth's crust—is a useful tracer for characterizing the mesosphere. Though this atmospheric layer contains other granules of metals, including iron, magnesium, calcium, and potassium—all produced by the evaporation of extraterrestrial dust when it encounters Earth's atmosphere—sodium is easiest to detect. Literally, a layer of sodium exists in the mesosphere.

Because of its relative abundance, sodium provides higher-resolution data that can reveal more information about the small-scale dynamics occurring in the upper atmosphere. From this, scientists can learn more about how weather in the lower atmosphere influences the border between the atmosphere and space.

The group has begun developing its instrument, which is electronically tuned to the 589-nanometer range, or yellow light. While in orbit, the lidar would rapidly pulse the light at the mesospheric layer, down one to three kilometers over a swath measuring four to eight kilometers in width.

The light's interaction with sodium particles would cause them to glow or resonate. By detecting the glow-back, the lidar's onboard spectrometer would analyze the light to determine how much sodium resided in the mesosphere, its temperature, and the speed at which the particles were moving.

Scientists have used sodium lidars in ground-based measurements for at least four decades, but they never have gathered measurements from space. As a result, the data is limited in time and space and does not offer a global picture of the dynamics. With a specially designed spaceborne sodium lidar, however, scientists would be able to illuminate specific areas, revealing the small-scale dynamics that currently are the biggest unknown, Janches said.

The team will use NASA's funding to fine-tune the technology that locks the lidar onto the sodium lines. "It's like a guitar string," Krainak explained. "If you want a certain tone, you need to lock down the string at a particular length. It's the same thing with the laser cavity length."

The team also plans to demonstrate an environmentally tested engineering test unit of the laser, thereby improving its technology-readiness level to six, which means that the technology is ready for flight development.

"We've made significant progress on the laser," Krainak said. "If we win, we could be the first space-based sodium laser spectrometer for remote sensing."

Provided by NASA's Goddard Space Flight Center

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