NASA advances world's first spaceborne sodium lidar

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It's used as a coolant in nuclear power plants and as a desiccant to remove humidity that otherwise would ruin moisture-sensitive products. Found in every cell in the human body, it transmits nerve impulses and regulates blood pressure. And as it turns out, sodium—the sixth most abundant element in Earth's crust—also is useful as a tracer for characterizing Earth's mesosphere, a poorly understood region of Earth's atmosphere that's sensitive to both the influences from the sun above and the atmospheric layers below.

A team of scientists at NASA's Goddard Space Flight Center in Greenbelt, Md., now wants to develop the world's first spaceborne sodium lidar that would illuminate the complex relationship between the chemistry and dynamics of the mesosphere that lies 40-110 miles above Earth's surface—the region where Earth's atmosphere meets the vacuum of space.

Though this relatively small region 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. This dust is part of the so-called Zodiacal Dust Cloud that originates from the debris produced by asteroids and comets.

"There is literally a layer of atomic sodium in the mesosphere," said Principal Investigator Diego Janches, who is leading the lidar-development team. "When you shoot yellow light into the region, the light bounces off the sodium particles, causing them to resonate, or glow. By detecting the glow-back, you can measure how much sodium is in the mesosphere, its temperature, and the speed at which it's moving."

And because of its relative abundance, sodium provides higher-resolution data that reveals more information about the small-scale dynamics occurring in the upper atmosphere. From this, scientists can learn more about the influence of the Sun's energy, helping to differentiate its effects from that of humans.

Although scientists have used sodium lidars in ground-based measurements for at least four decades, they never before have gathered data from a spaceborne instrument. As a result, the data is limited in time and space and does not offer a global picture of the dynamics. "We want to do this from space," Janches added. "We want to map the entire mesosphere by the fluorescence of sodium."

To achieve that end, the team is using Goddard research-and-development program funding to advance the lidar technology, with the aim of first demonstrating it on the International Space Station. In addition to studying the influences of the sun on Earth, the instrument is ideal for studying other planetary atmospheres, Janches added.

Although NASA'S Thermosphere, Ionosphere, Mesosphere Energetics and Dynamics (TIMED) spacecraft—whose mission NASA has extended several times since its launch in 2001—has given scientists their first long-term look at this poorly understood region of Earth's atmosphere, the team believes its instrument concept is the logical next step.

"Because of TIMED's high inclination, it takes 60 days for the satellite to cover all longitudes at all local times. As a result, data from the satellite's SABER instrument (Sounding of the Atmosphere using

Broadband Emission Radiometry) assume that the dynamics are constant during that time," Janches said. "In addition, SABER is a scanning-type instrument. In other words, it looks at the horizon, gathering signals from all parts of the atmosphere."

In sharp contrast, the sodium lidar will illuminate a specific spot and gather data from that spot only. "Because of this, we get small-scale dynamics, which are the biggest unknowns," Janches explained. "And they are important. They are believed to be the major driver of circulation in the upper atmosphere."

Team Leverages Instrument Heritage

Mike Krainak, a team member and recognized expert in laser technologies, also believes NASA would benefit from such a spaceborne instrument, which he says poses few technological risks.

"We have a lot of leverage from other missions we've done," he said, adding that his colleagues already have developed laser-related technologies for the Geoscience Laser Altimeter System on the NASA ICESat (Ice, Cloud, and land Elevation Satellite) mission and the Atmospheric Laboratory for Applications and Science, a space shuttle payload. The laser itself, developed in large part by team member Tony Yu, is a modified version of the lasers flown on NASA missions to Mercury and Mars.

"All of the laser components are the same," Janches said. "This work has put us 20 years ahead and saved us $30 million in development costs. We have a general idea of what's going on," he continued. "We just want to get a bigger picture."

Provided by NASA's Goddard Space Flight Center