NASA HS3 instrument views two dimensions of clouds

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The second Cloud Physics Lidar built to fly on NASA's unmanned Global Hawk aircraft. In this summer's Hurricane and Severe Storm Sentinel or HS3 mission, the CPL is studying the changing profile of the atmosphere in detail to learn more about how hurricanes form and strengthen. Credit: NASA

NASA's Cloud Physics Lidar (CPL) instrument, flying aboard an unmanned Global Hawk aircraft in this summer's Hurricane and Severe Storm Sentinel, or HS3, mission, is studying the changing profile of the atmosphere in detail to learn more about how hurricanes form and strengthen.

"CPL profiles the atmosphere to get a two-dimensional picture of cloud and aerosols, from the top down," said Matt McGill of NASA's Goddard Space Flight Center in Greenbelt, Maryland, who led the instrument team that designed and built the CPL. Its data, presented as if it were a curtain hanging from the sky, shows what's in the atmosphere's different layers.

From about 60,000 feet on the Global Hawk, twice the altitude of a commercial plane, 94 percent of the atmosphere lies below the instrument. The lidar works by sending rapid pulses of light that, like a radar beam, bounce and scatter off any particles they encounter, such as cloud droplets or dust particles. Some of the scattered light returns to the instrument where it records how long it took for the photons to leave and return – giving the altitude of the particles.

CPL sends out 5,000 pulses of light per second in three different wavelengths, allowing the science team to discriminate between different types of particles, McGill said. "Is it a cloud made of water? Is it a cloud made of ice or mixed [water and ice]? And we can say something about what type of airborne particle we are seeing. Is it dust or smoke or pollution?"

For the scientists studying hurricanes, those distinctions are important. One of the major areas of study is how Saharan dust off of Africa travels across the Atlantic and affects hurricane formation and intensification. CPL data have been used to verify model projections of Saharan dust in the tropics. The CPL data showed dust layers had a vertical distribution different than models predicted. Instead dust layers occupied narrower altitude ranges. The finding led to an improvement in the dust models, which then feed into hurricane models.

Situated in the nose of the Global Hawk flying over the storm environment, CPL also has a role in on-the-fly mission planning. While in flight, the CPL sends its data back to the team on the ground. "The mission scientists involved in the flight planning can sit there and watch the data with us in real time and say, 'Oh, we're not getting what we want.' Then they can go work with the flight planners and pilots to reroute the aircraft into different areas," said McGill. "They love that."

The airborne science community takes full advantage of the quick look capability, as well as the 24-hour turn around for the final data products. CPL is one of the most flown instruments in NASA's Earth science fleet. "It's a workhorse for the field campaigns," said McGill.

The original CPL was built in 1999 and took its first flight on the ER-2 high altitude research aircraft in 2000. Over the years CPL has been used as a satellite simulator for ground validation efforts, a cloud spotter for other instruments needing a clear view of the ground, as well as the main data collector for scientists studying atmospheric composition and Earth's energy budget where thin clouds and aerosols are major players. The lidar was also part of the proof of concept flights for the A-Train, a series of satellites flying in the same orbit making near-simultaneous measurements of the Earth system using many different instruments. That proof of concept airborne campaign showed scientists the power of combining multiple Earth observing data sets.

In 2007, when talk began of using Global Hawks for Earth science, CPL was among the first sensors considered; its size is perfect for the instrument compartment. Worries about the untested Global Hawk led to a second nearly identical instrument being built for use on the unmanned aircraft. It flew on NASA's maiden Global Hawk Pacific campaign in 2009. Since then, the Global Hawk CPL has flown in two multi-year campaigns, alternating between the Airborne Tropical Tropopause Experiment (ATTREX) and HS3.

Compact and fully autonomous, the CPL lidar design pioneered photon-counting technology that has led to the development of two instruments that will fly in space, the Cloud-Aerosol Transport System (CATS), which launches to the International Space Station this December, and the Advanced Topographic Laser Altimeter System (ATLAS), which will fly on the Ice, Cloud and land Elevation Satellite-2 (ICESat-2) scheduled to launch in 2017.

The solid design of the instrument has borne up surprisingly well over the years, said McGill, who uses CPL as a learning tool for interns and young scientists getting their hands dirty in the field. Together, the twin CPL instruments have flown 26 missions. HS3 will mark the 27th overall and the seventh for the Global Hawk CPL.

"It's still going strong," McGill said.

Provided by NASA's Goddard Space Flight Center

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