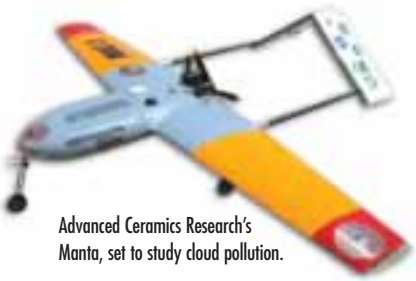
Unmanned Vehicles Expand Scientific Reach

Use of Unmanned Technology for Conservation is Growing



Advanced Ceramics Research's Manta, set to study cloud pollution.

Unmanned systems are not only making environmental research easier, they're literally changing the way scientists think about conducting research. From air to land to sea, unmanned systems represent some of the most exciting developments in biological, geological and atmospheric research.

Cloudy Skies

Famous for its laid-back culture, Los Angeles is also infamous for smog that can envelop the entire city and force citizens to seek safe air indoors. Dr. Veerabhadran Ramanathan, professor of atmospheric sciences and director of the Center for Clouds, Chemistry and Climate at Scripps Institution of Oceanography, began exploring smog 15 years ago while researching greenhouse gases.

"We used to think of it as smog, but now we think of them as brown clouds," he says. "They can cover whole continents."

In the past, scientists rented manned airplanes to collect air pollution data. Two years ago, Ramanathan lead an international team, flying three synchronized unmanned aircraft—one above, one below and one inside the clouds. This summer, he will examine brown clouds full of particulates that move across the Pacific Ocean from Asia. Two Advanced Ceramics Research-built Manta vehicles will fly vertically up and down to capture data from clouds originating in China and other countries during and after the Olympic Games.

The Arctic from the Air

"Imagine if you put ice cubes in a glass that is empty, then add water. The ice floats," says John Adler, a graduate student at the University of Colorado at Boulder and a NOAA Corps Officer at the U.S. National Oceanic and Atmospheric Administration (NOAA).

The ice sheets in Greenland contain mulons, cracks that can stretch to the bottom, fill with water and cause the ice to float and melt faster. Adler is leading a NOAA-funded project, Arctic Muscox (multisensor cryospeheric observation experiment), that will use the UAS to map the ice sheet surface.

"The ice sheets have been melting for the last several decades but the melting has been really rapid in the last 10 years," says colleague Betsy Weatherhead at the Cooperative Institute for Research in Environmental Sciences (CIRES), which is jointly sponsored by NOAA and the University of Colorado at Boulder. "The ice sheets are very important because they raise the sea level as they melt. So, what happens in Greenland could easily affect Florida."

Flying unmanned aircraft allows researchers to use multiple vehicles. "If something goes wrong with plane one, we can use plane two," she says. "In the old days, we were using one [DeHavilland] Otter aircraft, and if something went wrong, you had to wait until it was fixed."

Sensor packs include a hyperspectral camera that can take pictures of lake depths in multiple frequencies and a laser that shoots to the ice sheet surface and reflects back. Dr. James Maslanik, associate research professor at the Colorado Center for Astrodynamics Research, developed the laser system over several years and the team integrated it and the rest of the sensor pack into a space only about one foot square. In addition, there are temperature sensors and a differential Global Positioning System. Arctic Muscox will connect with other research teams to compare data.

Ayanna Howard with a SnoMote, a robot designed to gather scientific data in ice environments. *Photo courtesy Georgia Tech.*

And from the Ground

At the Georgia Institute of Technology, Ayanna Howard, associate professor of electrical and computer engineering, rethought her approach to terrestrial robots. The former NASA researcher designed the SnoMote after teaming with colleague Magnus Egerstedt, an associate professor of electrical and computer engineering, and Derrick Lampkin, assistant professor of geography at Pennsylvania State University.

"The first [prototype] was a walking vehicle," Howard says. The six-legged SpiderMote could walk pretty well over rocks and terrain, but it wasn't sturdy, was hard to control and couldn't maintain enough stability for the sensor package. Although the second model sported wheels as well as feet, it was unsuccessful, too. With the third model, the team rethought the functionality issue.

"We asked ourselves, 'Minus the legs, when people go on the ice, what do they do?'" After looking at toy models of snowmobiles and skies, the team settled on the SnoMote. The prototype, which houses the software and sensor package in a child-size snowmobile, will be tested in Alaska before development of a full-scale model. "The whole goal is to create a robust enough platform [on which] to actually build a human-scale model with all of the required infrastructure" to survive the arctic, she says

The Depths

Off the New Jersey coast, Thomas Grothues, assistant professor at Rutgers University's Institute of Marine and Coastal Sciences, uses Hydroid's REMUS 100 underwater vehicle to track fish.

"This type of niche had previously been filled with ships and boats," he says. Grothues teamed with colleague Kenneth Able, a professor at the university, and Joe Dobarro, assistant director of marine operations at NOAA's Mid-Atlantic National Undersea Research Center, to study marine habitats with the Autonomous Underwater Vehicle (AUV).

Grothues has tracked fish in estuaries with acoustic transmitters since 2002, but says "there's a lot of ocean and I wanted to introduce a more active system ... You need to be able to go out and move with the fish to understand that part of the life cycle better."

The REMUS allows the team to monitor fish as they migrate into open water, and to take measurements of underwater conditions such as depth, dissolved oxygen, temperature and salinity.

Unlike ships and boats that take point samples, the AUV can take continuous, high resolution samples every two minutes and dive deep.

"We have been using the vehicle to measure the coastal areas but one of the strong applications for an AUV is to go into places where a boat can't," Dobarro says.

While they seek additional funding, the team is joining other university-based researchers on one- and two-day studies to examine anoxic events, conduct site scans, identify dead zones and track other species of fish. Given the costs for personnel combined with rising fuel prices, the AUV is an economical part of the work.

FORCES OF NATURE

As the severity of hurricane season storms increases, the environmental community sees an equally strong need to get a better picture of what's happening inside. The conditions and wind measurements could tell scientists much about the way hurricanes work. With funding from NOAA, the University of Colorado at Boulder may do just that.

"The most recent hurricanes have been really quite deadly," says CIRES' Weatherhead. "We've always been frustrated by the lack of information about the hurricanes. The UAVs seemed to be the right fit."

Getting close, much less inside, hurricanes has proven too dangerous for manned flights. Adler, who spent some time as a hurricane hunter, described a close call: "Once we were low, at about 200 feet, on the edge of a hurricane. It threw up all of this salt water and caused one of our engines to flame out."

With new methods of measuring hurricanes, researchers hope to improve forecasting and extend the timeframe for early warning systems, allowing for better preparation before a storm hits and reaction after it occurs.

The U.S. Geological Survey is part of a working group, led by the National Forest Service and NASA, that's been flying vehicles derived from General Atomics Aeronautical Systems' Predator over wildfire activities for three years. With advances in the capabilities of smaller

systems, the group is now looking at the feasibility of using smaller, cheaper systems to monitor fires for an extended period of time, and using multiple systems to increase consistency.

"One of the visions is that we'll be able to use technology to monitor activity and locate engines and men on the ground to coordinate with command centers," says Mike Hutt, the Geographical Survey's UAS program manager. "What we're looking at is not just platforms and sensor applications but also communications that have to be established."

An Untapped but Exciting Future

Although use of unmanned systems in environmental research has increased throughout the world, they remain a relatively untapped resource.

"In general, scientists are becoming much more open to technology, to autonomous technology. It doesn't take the scientist out of the loop," Georgia Tech's Howard says. "There is more of this synergy between scientists and engineers that we previously only had theories about but didn't have the data to back it up."

"There are so many issues in the environment where our knowledge is severely limited by the lack of data," says Weatherhead. "We don't know what's going on inside volcanoes. We don't know what's going on in hurricanes. We don't know what's going on in remote regions. We don't know what's going on deep underwater. And it's not safe to send a manned vehicle into these places."

Already, researchers dream of the possibilities. "If I think of 20, 30 years down the road, I think of nothing but robotic observations of what we're doing on the planet … almost all observations are unmanned with 20 or more units," Scripp Institution's Ramanathan says.

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FOR MORE INFORMATION:

Advanced Ceramics Research: http://www.acrtucson.com/

CIRES: http://cires.colorado.edu/

Colorado Center for Astrodynamics Research: http://ccar.colorado.edu/

Hydroid: http://www.hydroidinc.com/

Georgia Tech: http://www.gatech.edu/

NOAA: www.noaa.gov

Rutgers Institute of Marine and Coastal Sciences: http://marine.rutgers.edu/

Scripps Institution for Oceanography: http://www.sio.ucsd.edu/