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Measuring Rainforest Loss with SAR

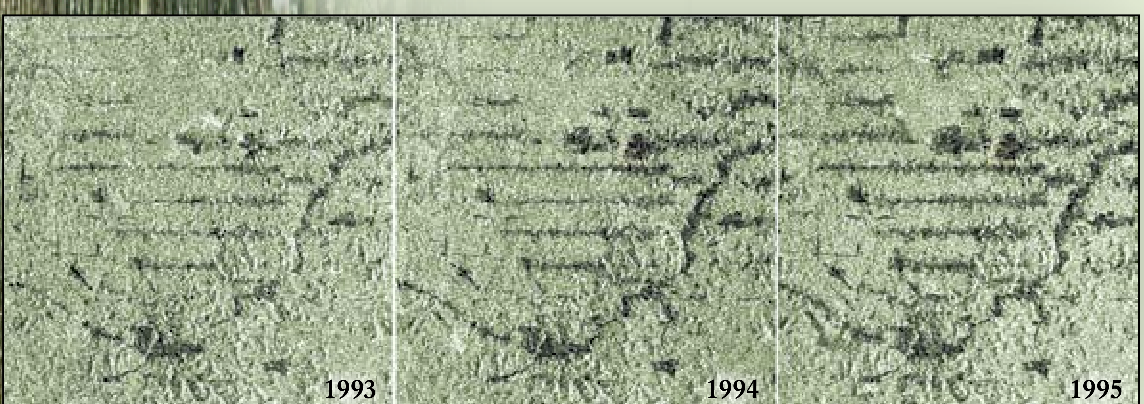
In this era of multiple views of Earth from high above the planet, deforestation of the Amazon rainforest is easier to document than it once was. However, thick cloud cover often limits viewing the rainforest with satellites in the visible and infrared parts of the spectrum, and cloud-free scenes are not available during some years.

Using synthetic aperture radar (SAR) data archived at the Alaska Satellite Facility (ASF), Geophysical Institute researchers recently produced a case study to document deforestation in the Amazon River basin near the state of Rondonia, Brazil. SAR technology enables users to receive data through clouds, fog, and darkness.

The scientists wanted to show how a wide spectrum of people, from middle-schoolers to graduate students, could easily work with ASF data. The rainforest project is one of a few dozen case studies the researchers have developed.

"ASF has an archive of data, and we want to make the data usable," said Anupma Prakash, a professor of remote sensing at the Geophysical Institute.

ASF Remote Sensing Scientist Rudiger Gens gathered data and used open-source (freely available) software for the project to demonstrate deforestation patterns and estimate extents. Emeritus Professor Shusun Li helped with image processing and interpretation. Candace O'Connor, a Geophysical Institute science editor, wrote up the case study, and science teachers David McGraw and Gary Cooper tested the study for its applicability in a classroom setting. The case study is to become a part of the Earth Exploration Toolbook, an online NASA-reviewed collection of educational curricula.



Alaska Satellite Facility image

__DEFORESTATION__–Above are SAR images of an area northwest of Rondonia, Brazil, from 1993 to 1995. The percent area of deforestation (shown in dark shades) increased from 15 to 23 percent in these three years, and in 1996 increased to 27 percent. In the background, a tree is harvested.

Amazon River basin wood harvesters work in a pattern that, from space, roughly resembles the skeleton of a fish, with one main line that has several shorter lines extending from it perpendicularly. The researchers determined from the SAR data that the fish-bone deforestation patterns in the Rondonia area increased from about 15 to 27 percent from 1993 to 1996.

The researchers' goal in producing case studies is to showcase the valuable data archived at ASF and illustrate how people can easily produce worthwhile studies with it.

"We want to encourage SAR data use," Gens said. "If you're not intimidated by the data, you'll use it."

ASF receives satellite data through a 10-meter dish atop the Elvey Building at the University of Alaska Fairbanks, and a similar antenna in the woods west of the building. ASF currently receives data from six polar-orbiting satellites.

UNIVERSITY OF ALASKA FAIRBANKS

Capturing Sprites

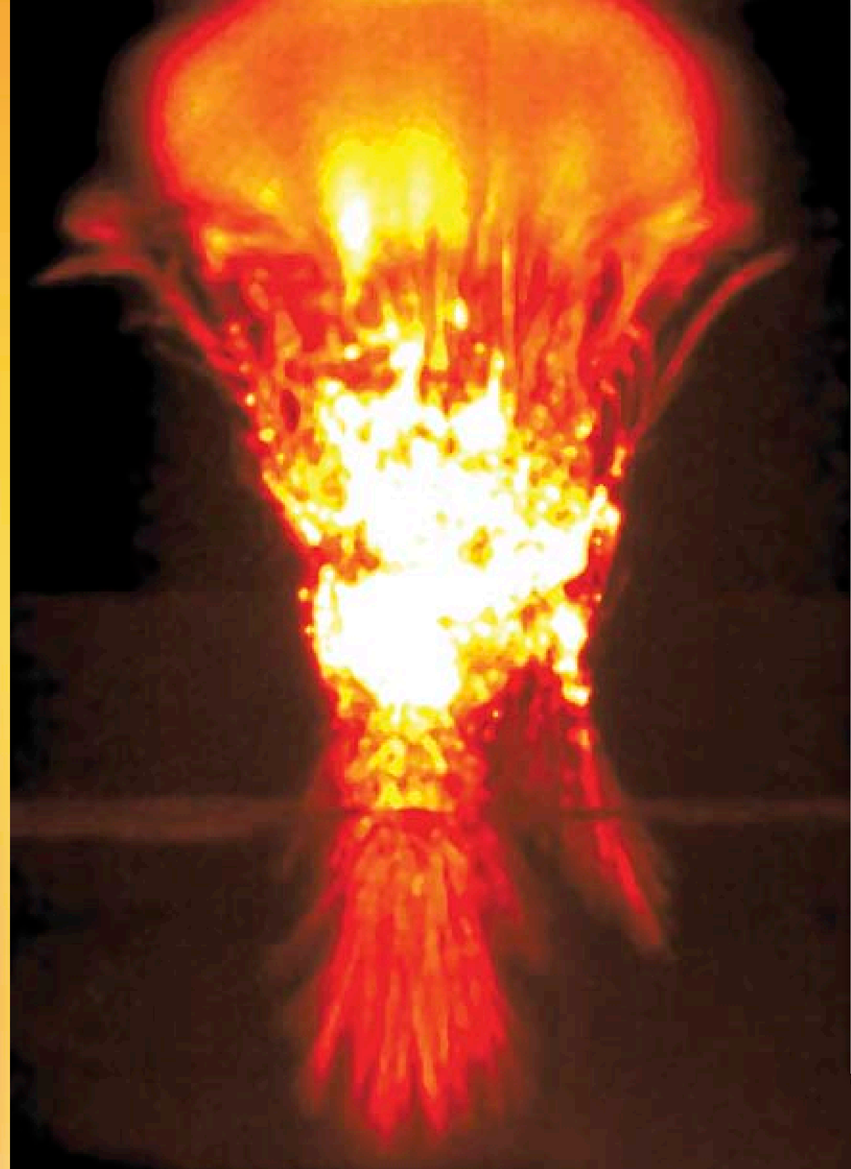
at Thousands of Frames Per Second

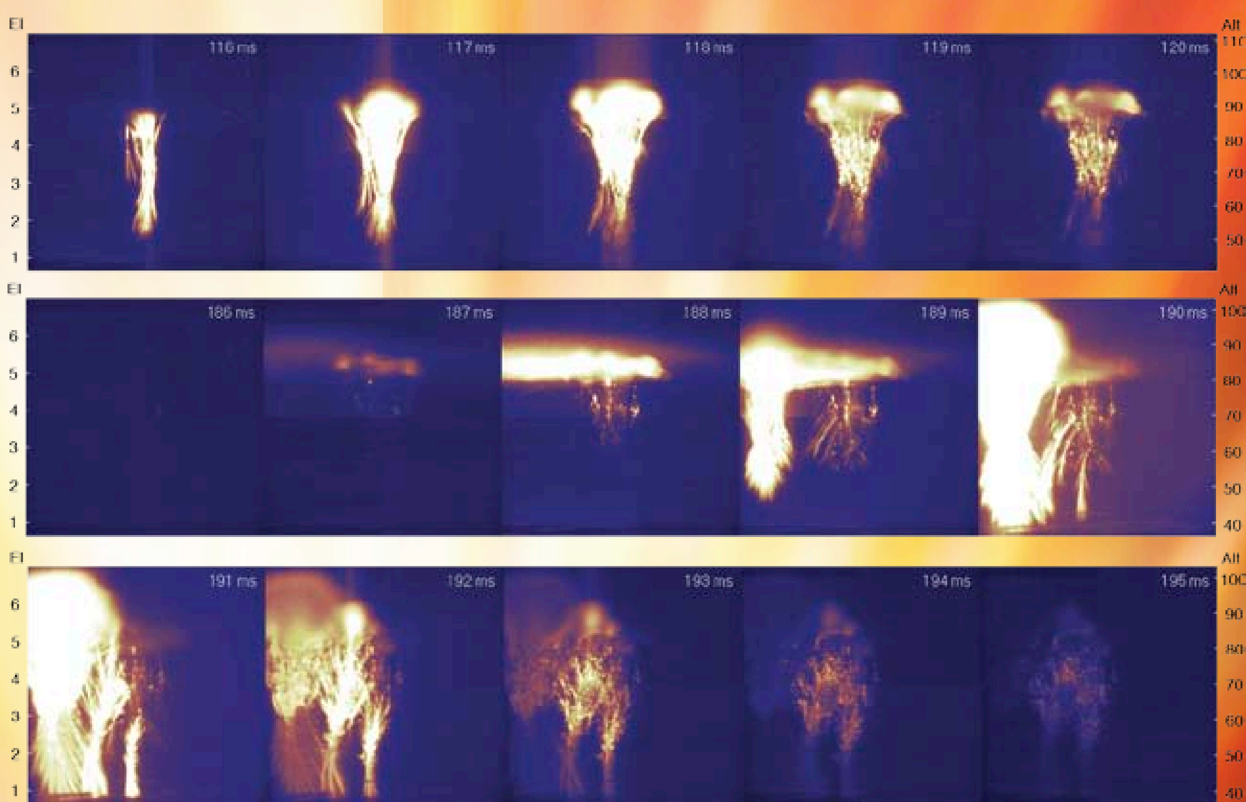
Geophysical Institute Associate Director Hans Stenbaek-Nielsen and Geoff McHarg, director of the Space Physics and Atmospheric Research Center at the United States Air Force Academy and a UAF alumnus, have used an intensified Phantom-7 high-speed camera that was developed at the Geophysical Institute to capture images of sprites at as many as 16,000 frames per second. This has provided a very different view of sprite development and changed previous notions of sprite dynamics. By comparison, a video camera shoots 30 frames per second.

Sprites are large, bright, short-lived optical emissions that occur above lightning activity at high altitudes of 60-90 kilometers. They were discovered in 1989, and Geophysical Institute Professor Davis Sentman and Professor Emeritus Gene Wescott captured them for the first time on video in 1994.

Stenbaek-Nielsen and McHarg wrote about the recent sprite developments in "High Time-Resolution Sprite Imaging: Observations and Implications," published in *Journal of Physics D: Applied Physics.*

"The downward propagating tendrils and upward propagating branches, so clearly identifiable in the earlier images, are actually fast moving streamer heads rather than luminous streamers," the researchers wrote.





SPRITES *– Pictured are images of sprites captured over a thunderstorm in Wyoming in 1999 using a camera developed at the Geophysical Institute by Tom Hallinan, Jim Desrochers and Hans Stenbaek-Nielsen. The images were taken at 1,000 frames per second; the institute's Davis Sentman added color to the lower set. Images courtesy of Hans Stenbaek-Neilsen.*

Unmanned Aircraft Perform above Fire and Ice

The crew at Poker Flat Research Range had a successful summer flying missions with unmanned aircraft, learning the nuances of the 40-pound device's operation in two extreme Alaska settings. The team worked in the freezing fog and moist air of the Bering Sea capturing images of seals in May and June; in August, team members helped firefighters overcome thick smoke just south of the Yukon River near Circle.

The Poker Flat team owns four Insitu ScanEagles, intelligent aircraft with the 10-foot wingspan of an albatross. Team members, experts on the operation and instrumentation of unmanned aerial vehicles, are now deciding where to focus their efforts in the growing industry.

photo by Martin Susser, Insitu, Inc.

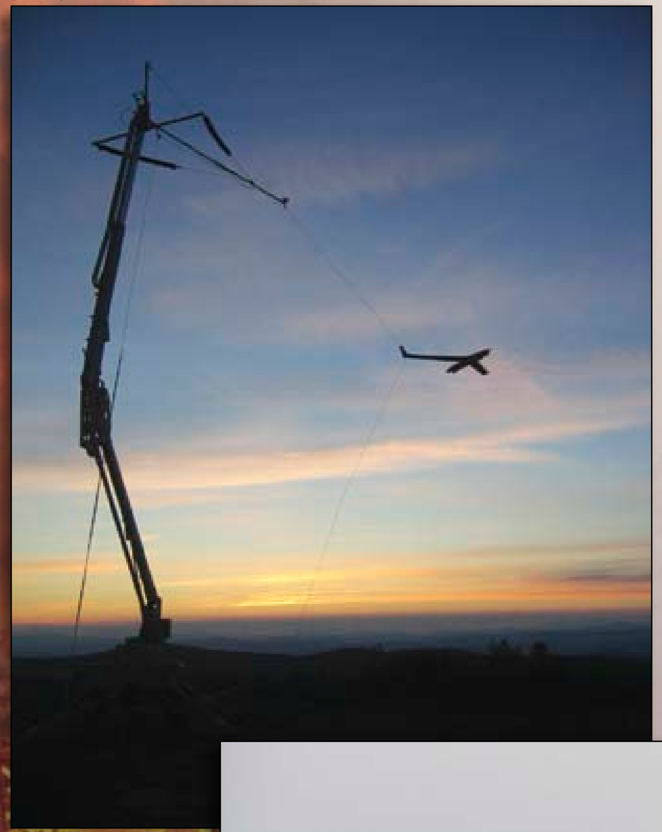


photo by Kevin Engle, Geophysical Institute

AIRCRAFT – At top left, the institute's unmanned aircraft is retrieved by hooking its wingtip on a suspended cable during a mission near Stuart Creek on Eielson Air Force Base in 2007. At bottom left, Optical Science Manager Don Hampton (left) and Insitu, Inc. Program Manager Martin Susser (right) load an unmanned aircraft onto its launcher in the summer of 2007 near Stuart Creek. Background fire photo by Tetlin NWR/USFWS.

Steese Highway, the heart of the Crazy Mountain Fire Complex

Range Manager Greg Walker and Optical Science Manager Don Hampton deployed the aircraft at the Crazy Mountain Fire Complex, a name fire officials gave four adjacent wildfires near the town of Circle on the Yukon River. The fires burned almost one-half million acres in late July and early August.

The aircraft flew from mile 145 of the Steese Highway beginning on August 5th. When Walker and Hampton arrived, smoky conditions had prevented helicopters and fixed-wing aircraft—and the technicians inside who mapped fires with the help of heat-sensitive cameras—from flying for more than five days. Firefighters had thermal satellite information, but they hadn't been able to precisely update the boundaries of the fires.

Walker and Hampton helped fire managers with a question they couldn't answer any other way: did the fire jump the natural firebreak of Birch Creek, thereby threatening Circle Hot Springs, Central, and Circle?

Thermal satellite images showed that fire was near the creek, but its resolution was not fine enough to allow fire managers to see if fire had crossed the creek.

"You have heat in that one-by-one-kilometer pixel, but where is it?" Walker said.

Using the thermal sensor on the unmanned aircraft, the team was able to confirm that the fire had not breached the creek; it also collected GPS waypoints and images of the fire edge that allowed technicians to update fire maps and view fire behavior.

INSTRUMENT – Poker Flat Research Range Manager Greg Walker holds a synthetic aperture radar unit that will fit in the nose of an unmanned aircraft. Photo by Ned Rozell.

John Softich, the fixed wing specialist for the Bureau of Land Management Alaska Fire Service, said that the unmanned aircraft answered an important question for firefighters.

"Had the fire jumped (Birch) Creek, it would have been a free-for-all," Softich said. "They not only helped us tell whether it jumped the creek, but they helped us assign the precious few resources we had.

"Without them, (the fire edge) wouldn't have been seen for a few more days."

The edge of the pack ice, Bering Sea

Walker and Hampton spent a month on the NOAA ship McArthur II with biologists who were looking for seals that live on and around the northern ice. Researchers with the National Marine Mammal Laboratory's Polar Ecosystems Program were looking at the abundance of bearded, spotted, ringed, and ribbon seals. Walker and Hampton were aboard to find seals with their small aircraft; they flew missions with an SLR camera they integrated into the aircraft's nose. The camera captured more than 25,000 images during the missions, and the aircraft flew for 42 hours total, whenever the weather allowed them to fly.

"We spent a lot of time looking at fog," Hampton said. "The Bering Sea seems to be a fog-producing machine."

Controlled by Hampton and Walker on the ship, the aircraft flew in a pattern over the ice and ocean similar to a path someone would walk while mowing a lawn—back and forth until an area was covered. The ScanEagle flew up to five miles from the ship—the farthest the Federal Aviation Administration would allow the unmanned vehicle to fly out of concern for collisions with other aircraft.

Walker said mid-air crashes were unlikely, due to the remoteness of the area and the 300-500 foot elevation of the mission's flight path. Unfortunately, the distance restriction kept the ScanEagle from providing the greatest possible value to the biologists.

"The FAA basically turned a science mission into an engineering mission," he said.

On a good weather day, Hampton and Walker flew the aircraft 364 total miles, compared to a 200-mile day that would be the maximum of a helicopter tasked with the same function.

Michael Cameron, a research biologist for the Polar Ecosystem Program out of Seattle, was studying the seals from the ship. If the distance restriction can be overcome by improved technology or some other means, he can envision a fleet of several unmanned vehicles someday flying a few hundred miles over the ice pack from a ship's deck.

"Being able to launch a UAS (Unmanned Aircraft System) from a ship NOAA owns, we don't have to work with the Coast Guard and pay a huge fee for icebreakers (with helicopters)," Cameron said. "We suspect it can be very effective at achieving our mission goals for less money."

The unmanned aircraft, sleek and quiet, also have the advantage of stealth.

"It's pretty clear that the UAS is much quieter than a helicopter," Cameron said. "The sound is like that of a weed whacker at 500 feet. (In the photos,) you don't see animals looking up at the camera."

The mission once again illustrated that unmanned aerial vehicles are ideal for some projects in remote country, Walker said.

"It's hazardous to put humans out there," Walker explained. "If you're out there (in a small airplane or helicopter) hundreds of miles from land, 400 feet altitude, if you have any problems at all, you're dead."

Other applications for the aircraft

Uses for the unmanned aircraft seem to be limited only by peoples' imaginations. Walker gave a few examples of using the aircraft as temporary radio repeaters by flying in tight circles (rather than deploying transmitters on mountaintops), and using the thermal imaging function to detect body heat during search and rescue missions.

"I don't know of a single natural-resource organization that isn't interested (in using unmanned aircraft)," Walker said. "NOAA's interested, NASA's interested, I don't know who's not."

Walker, who ran his own company that designed and made control systems for unmanned aircraft before coming to Alaska in 1998, recently purchased a compact synthetic aperture radar unit that will fit in the nose of the aircraft. The tiny SAR camera will allow the aircraft to discern straight edges of buildings and other structures no matter how thick a fire's smoke might be.

"It'll allow us to observe if there are structures inside the fire line," Walker said. "It'll let us get a cleaner signal of straight edges, with a 30-centimeter resolution. We could carry it along with a camera."

The U.S. military has used unmanned aircraft for battlefield reconnaissance in Iraq and elsewhere, and the present system is a descendent of an aircraft developed to help commercial fishermen locate and track schools of tuna.

Hampton said unmanned aircraft are ideal for jobs that are "dirty, dull, and dangerous," such as flying through thick smoke or over sea ice far from land. But there are better tools for some Alaska jobs, especially because getting permission from the FAA to fly unmanned aircraft over certain areas often takes months.

"If you just need three or four hours (of aerial photography), hire a Super Cub," he said.

Walker said he and other members of the team, which includes Hampton, Operations Manager Kathe Rich, and Special Projects Manager Ro Bailey, are convening often to find out where best to direct their efforts as opportunities arise.

"Ro, Kathe, Don and I are trying to focus on what we need to do to survive in the future," Walker explained. "This is our niche right now—showing people what (the unmanned aircraft) can do."

photo courtesy Greg Walker

photo courtesy Greg Walker

AT SEA – At bottom right, an image of a ribbon seal taken by the institute's unmanned aircraft while it flew from NOAA's ship the McArthur II from May-June, 2009. At top right, the institute's Insitu ScanEagle unmanned aircraft launches from the McArthur II in the Bering Sea. Background sea ice photo courtesy USFWS.

SEALS – The unmanned aircraft aided biologists researching seal populations. Ribbon seal pup photo by Michael Cameron, NOAA Fisheries.

Exploring Kasatochi
for Signs of Life

Chris Nye traveled twice in the summer of 2009 to Kasatochi Island, a stratovolcano located in the Aleutian Islands. On August 7, 2008, Kasatochi "blew up," as wrote the two biologists who narrowly escaped the eruption. Researchers returned in June and August 2009 to see what had survived on the island (a centipede, spider, and a few other insects; and plants that sprung from root wads protected by a blanket of ash) and to find out more about the nature of the eruption itself.

Nye, a geologist with the Alaska Volcano Observatory, and Willie Scott of the Cascades Volcano Observatory in Vancouver, Washington, found a rare white rock infused with long black crystals, a "cumulate hornblende gabbro." They think it might be part of the crystal-rich rind on the walls of the magmatic storage system that was carried to the surface by the magma. The rock is a key piece to deciphering the details of Kasatochi's eruption.

photos by Ned Rozell

VISITING THE VOLCANO *– At right, Chris Nye is pictured on Kasatochi Island with a rare rock that may hold clues about the explosive volcanic eruption there in August 2008.*

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