Geophysical Institute Quarterly

Volume 16: No. 2, 1999

Trying to Make Sense of Smoke

PHOTOS BY PAMELA STEWART

Geophysical Institute researchers Richard Collins and Catherine Cahill recently analyzed the way smoke interacts with the environment during a prescribed burn in the Little Poker Creek watershed. Their research may help determine how smoke in the atmosphere affects the local climate, both now and in the future.

Collins and Cahill were joined by several dozen scientists involved with Frostfire, the name given to the 800-acre burn located about 30 miles north of Fairbanks.

Collins, an assistant professor of electrical engineering, analyzed how smoke interacts with light during Frostfire. He used lidar, a system that consists of a laser and a telescope, to obtain a clear view of the mesosphere, a region about 50 to 80 kilometers above sea level.

Collins and summer interns Pamela Stewart and Sarah Thomas observed the bottom three kilometers of the atmosphere.

Acting like dense fog pierced by car headlights, smoke from the fire scattered light in all directions when struck by the laser.

By measuring the light returning to the telescope, Collins was able to profile the atmosphere directly overhead.

He determined the distribution of smoke particles at a variety of heights and analyzed the amount of scattering produced by different components in the smoke.

Collins hopes to find out how high fire aerosols lofted into the sky during the burn and how much the smoke changed the air column over Poker Flat.

Cahill, an assistant professor of chemistry, captured smoke particles with an instrument she installed on a 10-meter tower in the middle of the burn area. The instrument features a pump that pulls smoke and air into several chambers that contain sticky strips onto which different-size smoke particles affix.

Cahill will analyze the strips to determine the size of smoke particles in the air over time and to figure out how smoke from a forest fire evolves. The particles, which measure about 1/50th the diameter of a human hair, combine to produce haze as they scatter light.

These tiny particles are persistent in the environment. Aerosols of this size compose arctic haze and can create acid rain. They also can cause cardiopulmonary disease.

According to Cahill, future climate scenarios call for more wildfires, which will produce more smoke in the atmosphere.

"The role of smoke is still unclear," Cahill said.

Smoke can warm the climate by trapping long-wave radiation. By contrast, smoke can cool the air below, by reflecting and absorbing solar radiation before it reaches the ground.

Cahill hopes to quantify smoke that occurs as a result of wildfires in Alaska, where more than one million acres burned in 1999.

Because Frostfire occurred near Poker Flat Research Range, the staff provided housing and logistical support.

"Frostfire was more than a minor inconvenience to their normal operations, and they deserve our thanks for the use of their facilities," said Frostfire Project Manager Larry Hinzman.

The light-scattering properties of smoke are evident in the photos above taken during the Frostfire controlled burn north of Fairbanks. Geophysical Institute researchers analyzed how smoke interacts with the environment during the burn.

Forty Years from the Stone Age

Naive. Rebellious. Mystical. Syun-Ichi Akasofu keeps a list of these and seventeen other adjectives in his desk. They were written by reviewers who rejected his scientific papers at one time or another during the four decades he's been in Alaska. After serving 13 years as director of the Geophysical Institute, Akasofu moved his desk (and the list) next door, where he now works as the first director of the International Arctic Research Center (IARC). To the new job, Akasofu brings energy, tenacity, and the experience of a man who helped push the study of the aurora borealis from its infancy to adulthood. Along the way, he became one of the world's leading authorities on the aurora and raised millions to establish IARC, which houses scientists from around the world who study the circumpolar north.

His road has been bumpy, but rewarding. When Akasofu flew to Fairbanks from his home in Japan in 1958, little was known about the distribution and cause of the northern lights.

"As far as the aurora was concerned, we started out in the Stone Age," Akasofu said.

With advice from his mentor Sydney Chapman, Akasofu wrote his Ph.D. thesis on the Van Allen Belt, donut-shaped zones of charged particles trapped in Earth's magnetic field. Because no computers in Alaska were capable of calculating the electric current of the Van Allen Belt, Akasofu traveled to Goddard Space Flight Center in Maryland. During his research, Akasofu became convinced that the strength of the solar wind, a stream of charged particles from the sun, was not

Akasofu is shown above on Castner Glacier and below speaking with Hannes Alfven, a Nobel Prize winner in space physics.

PHOTOS COURTESY OF GEOPHYSICAL INSTITUTE ARCHIVES

Former graduate students (from left) Ron DeWitt, Charles Deehr, and Eugene Wescott met Akasofu when he landed in Fairbanks in 1958. DeWitt's sign says "Welcome." Deehr's sign says "Kill the dean of students."

Akasofu meets with Ching Meng (above left) and with Sydney Chapman and Jerry Romick (below from left). Meng earned a doctoral degree with Akasofu as a mentor. Chapman served as Akasofu's mentor.

Akasofu (above right) speaks with an all-sky camera technician during a 1970s NASA polar mission.

Akasofu at the future site of the Institute.

directly tied to the waxing and waning of the Van Allen Belt and the activity of the aurora.

Reviewers described Akasofu's hypothesis as "rebellious" because at the time it contradicted the beliefs of other space physics researchers. Years later, satellite images proved his idea was right.

After completing his thesis, Akasofu examined the auroral zone theory, an idea that had been in vogue since 1860. According to the theory, the aurora oc-curred in a circular zone over the poles all the time, like a perfect halo.

After scanning films from 100 all-sky cameras set up around the world, Akasofu saw that the aurora didn't form a perfect ring, but a deformed oval. Again, he had to ignore written abuse directed at his idea, and, again, satellite images showed his idea was right.

Akasofu's joy in questioning current standards led to his greatest discovery in auroral research: the aurora substorm, intense activity within a nightly display of aurora.

At the time, researchers believed the aurora changed over the course of an evening because its intensity was linked to the rotation of Earth.

While watching films from the 100 all-sky cameras, Akasofu noticed that in some places the aurora seemed to peak with activity as much as three times in a night. This observation contradicted the prevailing assumption that the aurora peaked only once each night.

To gather evidence to support his theory that the aurora could peak at high activity levels three or four times in one night, he convinced NASA and the U.S. Air Force to fly him from Boston to Alaska several times.

The plane flew at roughly the same speed Earth rotates, but in the opposite direction. By remaining at solar midnight as he flew, he saw the aurora go from quiet to active and vice versa several times.

The films he made on board the jet and satellite images confirmed his idea, which earlier had been rejected by the Journal of Geophysical Research.

Akasofu keeps his list of discouraging words to remind him of the nature of science. Throughout his 40 years of research, he's watched many theories come and go. The long-lasting ones, such as the substorm theory he developed in 1964, are the hardest ones for scientists to contradict.

But contradictions always arrive, and science evolves with new ideas. Akasofu advises researchers not to become discouraged by confusing results.

"When you find something that does not fit, don't throw it away," he recommends. "You may be wrong, but if you are convinced you're right, pursue it. You may be the one to establish the next theory or paradigm."

Akasofu met Kazuyoshi Yoshimura (above right), director general of the Communication Research Lab of Japan's Ministry of Post and Communications in 1994 to celebrate the addition of several Japanese instruments to Poker Flat Research Range.

Akasofu carves at a GI Thanksgiving.

Forty Years at the Geophysical Institute

1930—Akasofu is born in a Japan town at the foot of an active volcano.

1946—Congress establishes the Geophysical Institute for the study of the aurora and associated physics.

1956—As a student working in a magnetic observatory in Japan, Akasofu researches foreign universities to find a place to study the aurora.

1957-1958—During IGY (International Geophysical Year), all-sky cameras photograph the aurora worldwide.

1958—Akasofu arrives in Fairbanks.

1961—Akasofu's Ph.D. thesis, "A Study of Magnetic Storms and Auroras," is published.

1963—After reviewing 8,000,000 feet of aurora footage taken by all-sky cameras during IGY, Akasofu hypothesizes the aurora occurs as a warped oval, rather than a perfect halo, over Earth.

1964—Akasofu's theory of the aurora substorm is published. Akasofu becomes a professor of geophysics at the University of Alaska.

1968—Akasofu's paper on auroral and magnetic disturbance research, "Polar and Magnetospheric Substorms," is published.

1976—Akasofu receives the Chapman medal from the Royal Astronomical Society of London. Later honors include the Japan Academy Award, the AGU John Fleming award, and the UAF Edith R. Bullock Prize.

1981—Akasofu becomes one of the 1,000 most-quoted contemporary scientists in the world.

1985—Emperor Hirohito of Japan receives a private lecture on the aurora borealis from Akasofu.

1986—Succeeding Juan Roederer, Akasofu is named director of the Geophysical Institute.

1997—Akasofu helps raise more than $30 million for the proposed International Arctic Research Center (IARC).

1999—Akasofu becomes the first director of IARC; Roger Smith becomes the interim director of the Geophysical Institute.

Le Conte Glacier's Sprint to the Sea

PHOTO BY SHAD O'NEEL

Moving toward the sea at a daily rate of 30 meters, Le Conte Glacier is one of the fastest non-surging glaciers ever recorded. The glacier, located near Petersburg in Southeast Alaska, adds the equivalent of five-to-six million tons of water to the ocean each day.

Geophysical Institute scientists are studying the glacier to learn about the nature of temperate tidewater glaciers.

Paul Bowen, a high school teacher in Petersburg, first told scientists about the change in Le Conte Glacier, the southernmost tidewater glacier in North America. A former geologist, Bowen and his students measured the terminus of the glacier for more than a decade. When they saw icebergs clogging Fred-erick Sound in 1995, they called Roman Motyka, now an adjunct research associate professor at the Geophysical Institute. He witnessed the beginning of a dramatic calving retreat, in which portions of the glacier splashed to the ocean more than 50 times a day.

During the summer of 1999, the advance was measured by Geophysical Institute graduate student Shad O'Neel.

Le Conte Glacier twists from the mountains to the ocean, where gravity forces it through a funnel of granite at the terminus. The glacier is found in Alaska's Coast Mountains, one of the wettest areas in the world.

According to Geophysical Institute Glaciologist Keith Echelmeyer, nearly 90 percent of the glacier lies in an area that receives more snow than melts.

The researchers hope to determine a mass balance for the glacier by depositing magnets on the surface, finding them later, and seeing how much snow has fallen on them in the interim. They also want to figure out how much of the glacier is lost to calving. The speed of the glacier at the terminus may be linked to how the glacier calves.

The scientists also will examine the underwater hydraulics of the glacier by looking at factors such as how the subglacial water effects the mass of ice, and how underwater moraine alters the stability of the glacier. In addition, they will inspect seawater sediment from the glacier, and the effects of tides, weather, and cycles of light and darkness.

Echelmeyer will use a laser-profiling system aboard his plane to help determine if Le Conte Glacier is thinning because the terminus is drawing ice out from the body of the glacier, or if the terminus is retreating because the body of the glacier is thinning.

The glacier's gallop eventually may provide scientists with clues about climate change in the north.

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Permit No. 2
Fairbanks, Alaska

The *Geophysical Institute Quarterly* is published as a public service by the University of Alaska Fairbanks Geophysical Institute Information Office: **Kathryn Berry**, editor, writer; **Deborah Coccia**, graphic artist; **Ned Rozell**, writer; **Lynda McGilvary**, editorial assistant. Free subscriptions are available by e-mail at fygipub@aurora.alaska.edu, by phone at (907) 474-7558; by fax at (907) 474-7290, from the address above, or on-line at http://www.gi.alaska.edu. UAF provides equal education and employment opportunities for all, pursuant to applicable state and federal laws.