

Red Sprites Make Splash in Recent Research

A massive sprite “splash” was observed by GI scientists during a recent research mission. Sprites are upper atmospheric flashes that probably have existed as long as lightning storms, but were not captured on color video tape until 1994.

A Geophysical Institute research team, led by Professor Davis Sentman and Professor Emeritus Gene Wescott, viewed the large sprite splash shown on this page over thunderstorms in central Iowa in July. A video camera carried by a Gulfstream-2 aircraft captured the sprite and a splash of tendrils that reached upward from the cloud tops.

Sentman said the splash can be interpreted as a physical reaction to the sprite, an echo expressed in light energy.

During the mission, which involved the aircraft and two ground observation stations on Mt. Evans in Colorado and Jelm Mountain in Wyoming, sprites were recorded in the ultraviolet and near-ultraviolet wavelength ranges for the first time.

The recordings will enable researchers to further determine the character of the flashes by studying their non-visible radiation.

During the past several months, researchers have reviewed hours of video tapes from the mission, the latest in a series of studies designed to investigate upper atmospheric flashes.

In addition to sprites, researchers are analyzing elves, blue jets, and blue starters. Elves, like sprites, are giant, horizontal,

pancake-shaped flashes of red light that occur above lightning storms during positive cloud-to-ground lightning strokes.

Blue jets are cone-shaped flashes that propagate upward at speeds of about 100 kilometers per second to about 40 kilometers above the tops of clouds. Blue starters are similar but they don't reach the same

Video from the Gulfstream-2 aircraft verified the claim that ionization occurs within some sprites, lending credence to the theory that sprites may be electrical discharges.

Sprites also appear possibly to generate gravity waves, which act like expanding rings on the surface of a pond.

In the upper atmosphere, gravity waves are detected as light waves emitted from hydroxyl ions. The team also discovered blue starters—and by extension blue jets—are energetic enough to cause the ionization of nitrogen molecules in the air.

The researchers want to find out if the brightness and the number of elements in C-sprites (short for columniform sprites, the brief, parallel,

straw-shaped forms that initialize many sprites) are related to the current released in, and duration of, the lightning strike below it.



Sprite Splash—The red sprite “splash” pictured at right was captured by video cameras while flying over thunderstorms in central Iowa this summer. The splash may be a physical reaction to the sprite, an echo expressed in light energy.



AIRPLANE PHOTO BY VERONIKA BESSER/SPRITE PHOTO BY DANIEL OSBORNE

altitude, climbing only a few kilometers from the tops of clouds.

The Geophysical Institute team has studied upper atmospheric flashes from the continental United States to South America since 1993. They earned recognition for being the first to capture color images of sprites on video tape in 1994.

Institute researchers, including co-investigator Professor Hans Nielsen, Senior Project Engineer Daniel Osborne, Project Engineer Jim Desrochers, and graduate students Matt Heavner, Dana Moudry, Laura Peticolos, and Veronika Besser, were joined on the recent mission by scientists from both the Air Force Geophysics Laboratory and the Naval Research Laboratory.

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Crossing Political and Geological Boundaries

Researchers from the Geophysical Institute and Japan recently joined scientists in Russia for a workshop that focused on Kamchatka and the Aleutian volcanic arc, where steaming mountains and craters provide clues to processes occurring deep inside Earth.

The Kurile Islands and the Kamchatka Peninsula in Russia, and the Aleutian Islands and the mainland of southern Alaska are home to more than one hundred volcanoes and some of the largest earthquakes on Earth.

The Alaska segment of this continuous belt of activity has been host to the biggest eruption and the second-largest earthquake on Earth this century.

Volcanologists from the Geophysical Institute were among 170 researchers from the United States, Russia and Japan to meet during the first "International Seismic and Volcanic Workshop on North Pacific Subduction Processes" to study the arc, which is among the most classic, active examples of a subduction zone on our planet.

The workshop on the Kamchatka Peninsula in the Russian city of Petropavlovsk-Kamchatsky was held to help break down the political barriers that formed among the countries after World War II and during the Cold War.



PHOTOS BY NIKOLAI SMELOV WITH THE INSTITUTE OF VOLCANOLOGY, FAR EAST DIVISION OF RUSSIAN ACADEMY OF SCIENCES

Studying the area is important for basic research and for hazard mitigation, according to workshop co-chairs Professor Boris Ivanov, from Russia, and GI Professor John Eichelberger.

More than 20,000 passengers fly over the volcanoes in the region each day. Those volcanoes erupt and send ash into the air to flight levels four or five times each year. The geological processes that result from the Pacific plate diving underneath the North American plate endanger Dutch Harbor, the busiest seafood port in the U.S. Tsunamis generated by earthquakes in the region can affect the Pacific Rim.

Despite these hazards, the area often is overlooked because scientists tend to study other subduction zones in the Pacific "Ring of Fire," notably those on the west coast of Central and South America, the South Pacific, the Philippines, and Japan.

Eichelberger speculates that northern areas may escape attention because they are less populated.

"If we are going to understand subduction on our

planet Earth, we have to focus on this zone and understand it," Eichelberger said.

The Russians have installed 30 seismic stations on Kamchatka, and the Alaska Volcano Observatory has placed about 120 seismometers on volcanoes that form the eastern part of the Aleutian Arc.

AVO is expanding the network westward and, during the past five years, Russian volcanologists have met with Americans to share information about Kamchatka volcanic eruptions and seismology.

The workshop was the first to take advantage of the growing opportunity for international collaboration among volcanologists. Eichelberger hopes it will encourage future research partnerships among countries.

The workshop likely will spawn several joint projects on volcanoes in the Aleutians and on the Kamchatka Peninsula. Scientists already have agreed to hold a second meeting in Alaska in the fall of 1999.

***Russian Volcanoes**—Avachinsky Volcano towers over the city of Petropavlovsk-Kamchatsky, Russia (above), where the first "International Seismic and Volcanic Workshop on North Pacific Subduction Processes" was held. At left, ash rises from Karymsky Volcano, also in Russia.*



The First Complete Radar Map of Antarctica

Researchers from the Geophysical Institute recently helped NASA scientists compile the first complete radar map of Antarctica (shown below). Other maps of Antarctica were produced in the 1980s, but they were made with conventional sensors that could not penetrate cloud cover. Consequently, some areas of the Antarctica surface were obscured. Synthetic aperture radar (SAR), which can "see" through clouds and darkness, enabled scientists to take their first complete look at the vast continent.

"Antarctica was the only place on Earth that had not been mapped by radar in snapshot mode," said Nettie LaBelle-Hamer, the Antarctic Mapping Mission Coordinator.

Snapshot mode refers to gaining an image in an instant in time. A collage of these images were put together to complete the new map. Because the mosaic enables scientists to see how Antarctica looked during one moment in history, it can be used as a base line for future research.

During the mapping mission, scientists and technicians from the Geophysical Institute worked with the Jet Propulsion Lab and Ohio State University to receive and compile data. The project required cooperation among a variety of scientists and agencies.

RADARSAT, a Canadian satellite, was used to collect images of the continent of Antarctica in September and October, 1997. During that time, the Alaska SAR

Facility devoted both of its satellite receivers to RADARSAT, which downloaded its data whenever it traveled above the horizon. The allocation of resources

into the ideal orientation. The move was a gamble; they risked losing the satellite by changing its alignment.

"Canada took a great risk by turning the satellite over," LaBelle-Hamer said, "but the results achieved already have proved worth the risk."

Orbiting at 800 kilometers, the satellite gathered 37 hours of data during the three-week period. ASF scientists and technicians processed the data and combined 5,500 images, each covering 100 square kilometers, into the map of Antarctica.

The mapping mission, designed to gather base line information on ice floes and other features of Antarctica, became even more valuable recently when the U.S. National Mapping Agency declassified satellite photos of the continent taken in the early 1960s. Scientists now can compare the photos to the radar images to see changes in Antarctica over the past few decades.

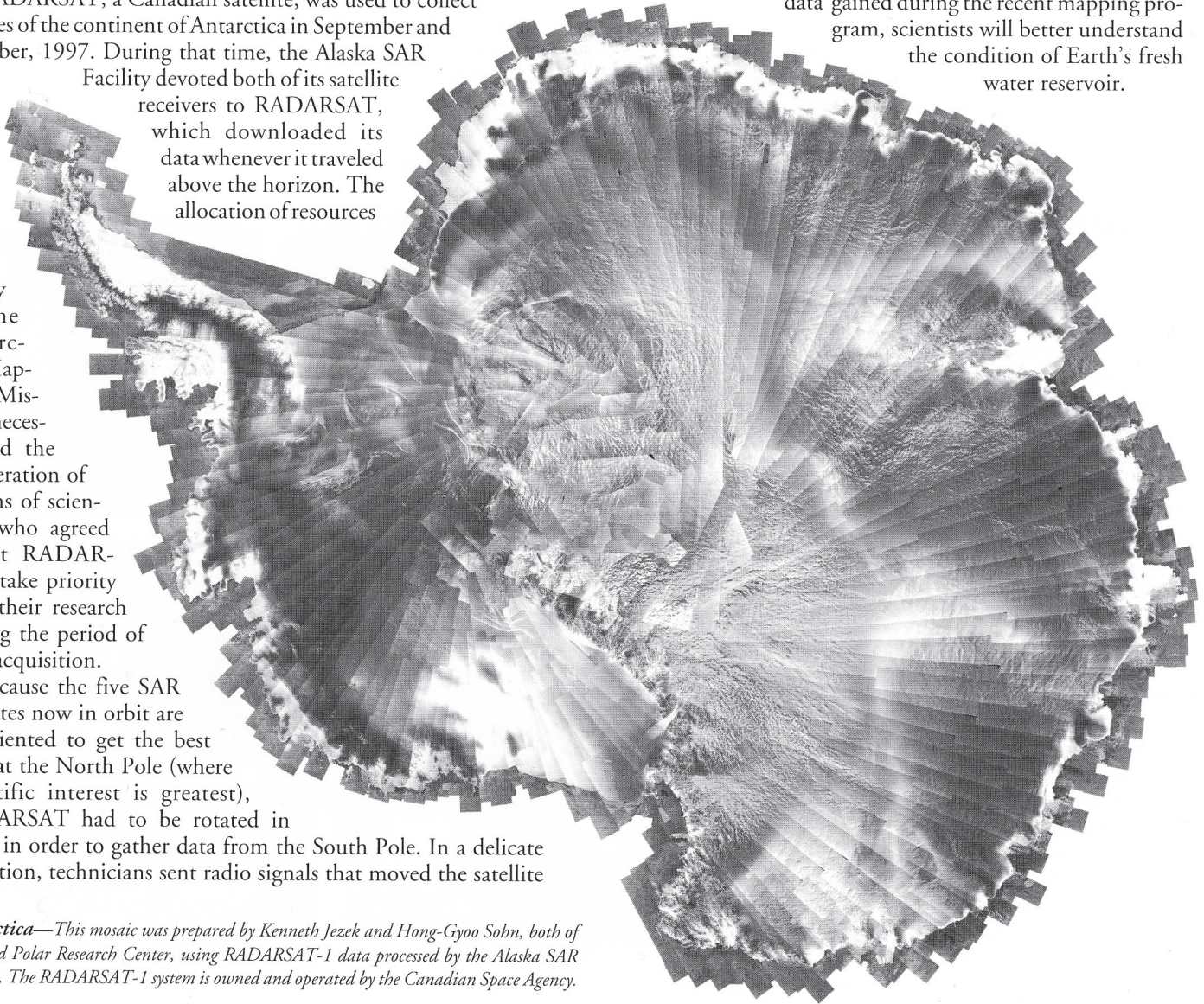
A change of major concern is the melting of ice sheets. Almost 70 percent of Earth's fresh water is stored as ice in Antarctica. Major melting there directly affects sea level. Researchers at the GI, NASA, and Ohio State University hope to map Antarctica again in the next century. By comparing those results with the

data gained during the recent mapping program, scientists will better understand the condition of Earth's fresh water reservoir.

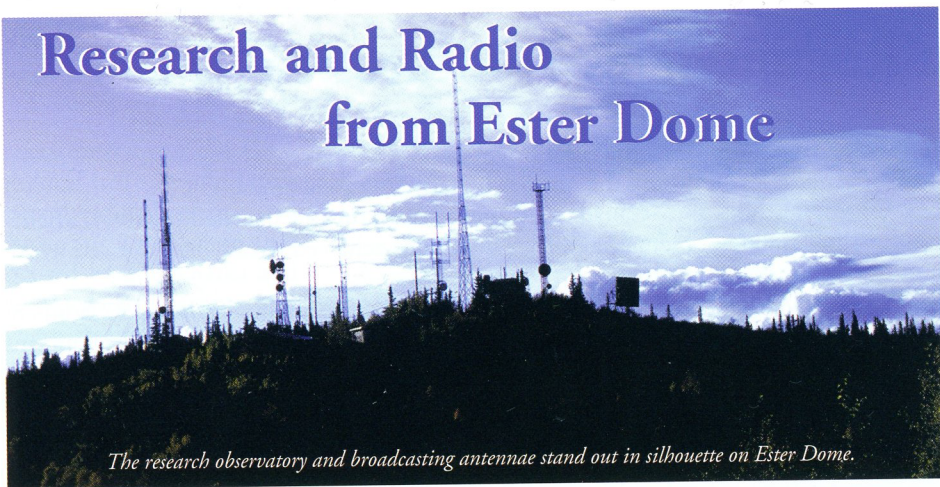
solely to the Antarctic Mapping Mission necessitated the cooperation of dozens of scientists who agreed to let RADARSAT take priority over their research during the period of data acquisition.

Because the five SAR satellites now in orbit are all oriented to get the best look at the North Pole (where scientific interest is greatest), RADARSAT had to be rotated in space in order to gather data from the South Pole. In a delicate operation, technicians sent radio signals that moved the satellite

Antarctica—This mosaic was prepared by Kenneth Jezek and Hong-Gyoo Sohn, both of the Byrd Polar Research Center, using RADARSAT-1 data processed by the Alaska SAR Facility. The RADARSAT-1 system is owned and operated by the Canadian Space Agency.



Research and Radio from Ester Dome



The research observatory and broadcasting antennae stand out in silhouette on Ester Dome.

The Geophysical Institute's Optical Observatory on Ester Dome has been home to auroral researchers, forest fire fighters, and atmospheric scientists since 1961.

For more than a year now, the battle-ship-gray building has added to its varied history by helping a public radio station strengthen its voice throughout interior Alaska. KUAC FM is broadcasting from the 2,400-foot Ester Dome site with the aid of a new 190-foot tower, 38,000 watts of power, and an agreement with the Geo-

physical Institute. The new tower stands on a concrete pad next to the optical observatory; the transmitter is housed inside the building.

Geophysical Institute Operations Manager Bob Grove arranged the agreement with KUAC, a radio station based at the University of Alaska Fairbanks. KUAC's transmitter and antenna were formerly stationed on Bender Mountain, a hilltop above Farmers Loop in Fairbanks, where their television transmitter remains.

The relocation to Ester Dome raises the antenna about 1,100 feet. That elevation gain allows KUAC-FM to greatly expand its range because a frequency-modulated (FM) signal can reach any receiver in its line of sight.

KUAC Engineer Tom McGrane said the Institute's optical observatory, with its 360-degree view of interior Alaska, is the best transmitter site in Fairbanks.

Decades ago, Ester Dome also was considered to be one of the best places in town to observe the aurora. In the 1960s, Institute scientists produced spectacular footage of the aurora by using specialized television cameras aimed through clear domes on the observatory roof.

However, the observatory's popularity as an aurora-watching site waned over the years due to encroaching light pollution from the north caused by people settling in Goldstream Valley and Fairbanks.

No aurora-viewing cameras are stationed at the observatory today. Geophysical Institute scientists opt instead for the darkness that surrounds Poker Flat Research Range.

Professor Emeritus of Geophysics Tom Hallinan remembers the advantages and

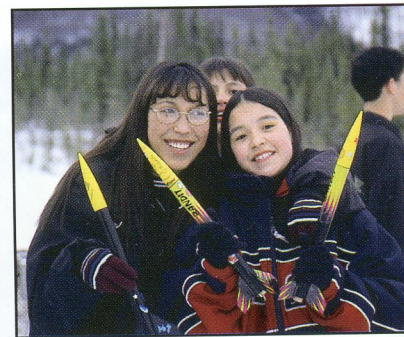
Science and Math Enrichment Program

The Geophysical Institute's new Science and Math Enrichment Program provides an opportunity for middle-school students from rural Alaska villages to visit the Geophysical Institute and other research centers at the University of Alaska Fairbanks.

The Enrichment Program, which is funded by the U.S. Department of Education through a three-year grant awarded to the Institute's Information Office, aims to inspire Alaska Native students to excel in science in high school and to pursue higher education and science careers later in life.

Nearly 50 Institute and UAF researchers worked with Alaska Native students from the rural village of Galena during the first five-day Enrichment Program on the UAF campus last spring. A new group of middle-school students from Galena, a 90% Athabascan Indian village of 550 people located on the Yukon River, will attend the Enrichment Program this spring.

All of the hands-on lessons in the Enrichment Program are based on recent geophysical research, and are designed to show students how math and science skills are used by professionals to solve real-life





Photos of antennae at Ester Dome by Evelyn Trabandt

disadvantages of auroral research at the observatory at Ester Dome.

In addition to being an excellent place to view the aurora, scientists used the Ester Dome site to track rockets launched from Poker Flat Research Range. Tracking rockets from Ester Dome was convenient when the weather cooperated.

Ester Dome, located a few miles from the main UAF campus, is nearer to most scientists' Fairbanks-area homes than Poker Flat Research Range, which is about 33 miles north of town.

"It was close," Hallinan said of the Ester Dome observatory. "I'd see an (auroral) arc from home and then head right up there. I think my record from door to door (home to observatory) was 15 minutes."

The problem with tracking rockets from Ester Dome is that the weather surrounding it often is different than the weather hovering over Poker Flat.

"Tracking rockets from Ester Dome was frustrating because it could be clear as a bell at Poker Flat, but we couldn't launch the rocket because it was cloudy at Ester Dome," Hallinan said.

Atmospheric scientists also have used the observatory for research projects but,

over the years, the encroachment of cars and other air-pollution sources has driven them to more remote areas.

During the 1970s, the Geophysical Institute permitted the Bureau of Land Management to use the observatory on Ester Dome as a fire watch base and a shelter; BLM employees lived in the building during the fire season. The building was used as a base for fire watchers until 1978.

Although much of the research from Ester Dome has ceased, the observatory still serves a vital function for the Geophysical Institute. A microwave antenna and equipment there serves as a communications link between the Elvey Building and Poker Flat.

The observatory's added function as a radio broadcasting station began last year, when the station broadcasted on both 104.7 MHz and 89.9 MHz, McGrane said.

The station received a \$268,198 grant from state and federal sources to erect the self-supporting radio tower and to purchase the transmitter and related equipment. In June, KUAC began broadcasting on 89.9 MHz exclusively; the 104.7 MHz frequency was sold to a commercial station.



PHOTOS BY EVELYN TRABANDT



GI scientists help students learn about geophysical research through hands-on activities during a five-day Enrichment Program at UAF.

problems in Alaska. During the Enrichment Program, students launch handmade rockets at Poker Flat Research Range; learn how to interpret satellite data at the Alaska Synthetic Aperture Radar Facility; forecast the movement of ash plumes with computer images produced by the Alaska Volcano Observatory; and determine the epicenter of a seismic event with researchers at the Alaska Earthquake Information Center.

Students also interpret weather maps and record radiosonde data gathered by weather balloons released twice daily by the Fairbanks branch of the National Weather Service.

In addition, students learn about global warming and climate change by visiting the NSF Research Greenhouse on the UAF campus and by interacting with a computer program designed by the Fairbanks data collection site for the Atmospheric Radiation Measurement Program (ARM).

The ARM site on the North Slope of Alaska is one of three places in the world funded by the U.S. Department of Energy to gather information about weather that can be used to forecast local and global climate change.

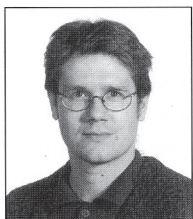
GI Notes

WELCOME



Cathy Cahill joins the Geophysical Institute as an Assistant Professor of Chemistry. Cahill completed her Ph.D. (1996) in atmospheric science at the

University of Nevada Reno Desert Research Institute, where she worked for 10 months before coming to Fairbanks. Cahill also spent 11 months in Galway Ireland on a Fulbright Fellowship.



Jerry Harrington joins the Institute as an Assistant Professor of Atmospheric Science. He received his B.S. (1991) at the University of Iowa, and his M.S. (1994)

and his Ph.D. (1997) at Colorado State University. Harrington specializes in cloud physics.

Wei Li joins the Institute as a Visiting Scientist working with Knut Stamnes. Li earned her B.A. (1982) at the University of Science and Technology of China and her M.A. (1985) at the Institute of Space Physics at the Chinese Academy of Science.

Dan McNamara recently joined the Institute as a Seismologist for the Alaska Earthquake Information Center. McNamara earned his B.S. (1987) at Central Michigan University, his M.S. (1990) at the University of Missouri, and his Ph.D. (1995) at the University of South Carolina. His previous research involved the study of tectonics on the Tibetan plateau, where he applied seismic techniques for verification of the comprehensive nuclear test ban treaty at Lawrence Livermore National Laboratory.

PROMOTIONS

Douglas Christensen has been promoted to Professor, and **Richard Benner** has been promoted to Associate Professor. **Benner** is serving as the leader of the Atmospheric Sciences Group, and **Peter Olsson** is serving as deputy group leader. **Martin Jeffries** has been promoted to

Research Professor, **Shusun Li** has been promoted to Research Associate Professor, and **Richard Collins** has been promoted to Assistant Professor. **Jeffries** was selected as the incumbent for the Office of Naval Research Chair on Arctic Marine Science for Fiscal Year 1999. This one-year appointment began in October 1998 at the Naval Postgraduate School in Monterey, California.

Professor of Physics **Roger Smith** has been promoted to Associate Director of the Geophysical Institute.

HONORS

The 1997 *Edith R. Bullock* prize for excellence was awarded to Geophysical Institute Director **Syun-Ichi Akasofu**. The UA Foundation sponsors the prestigious award, which recognizes individuals for their outstanding work in support of the University of Alaska.



Jeff Cook greets Dr. and Mrs. Syun-Ichi Akasofu.

The 1997 *Allen Prize* was presented to Assistant Professor **Richard Collins**. While working as a graduate student, Collins made outstanding contributions to atmospheric remote sensing using electro-optical instrumentation.

The 1997 *Emil Usibelli Award for Distinguished Research* was presented to Professor of Physics **Davis Sentman** and Professor Emeritus **Gene Wescott** for their significant contributions to science through their observations, analyses and publications on atmospheric and space physics, and for their investigations of red sprites and the discovery of blue jets, which have brought widespread recognition to the University of Alaska Fairbanks.

The 1997 *Terris and Katrina Moore* prize was given to Associate Professor **Richard Benner** for his consistent and impressive contributions to research, especially for his work on Earth's sulfur cycle, which has been based on a combination of hypotheses testing, instrument development, and theory. Benner recently published a paper on the determination of flux dimethyl sulfide from the ocean by an eddy correlation measurement using an instrument he invented himself.

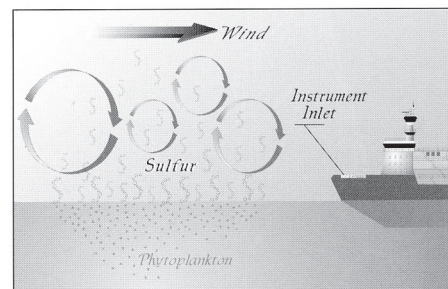


IMAGE BY DEB COCCIA

Tom Immel, Ph.D. graduate student in space physics received an Outstanding Student Paper Award at the Fall 1997 American Geophysical Union meeting in San Francisco. Only 10% of the papers presented by students received this high honor.

Microcomputer Specialist **Jesse Atencio** won the AFL Alaska Web Site award, a weekly award presented to Alaskan sites in appreciation for outstanding content and for valuable service provided to the Internet community.

GI Property Officer **Rick Danielson** received the designation of Certified Professional Property Administrator. The Certified Professional Property Administrator must pass a series of fourteen tests with a score of 75% or better and document at least three years of work experience in the property management profession.

EMPLOYEE RECOGNITION

Outstanding Staff Performance awards were received by: **Jan Curtis**, who works as the Climatologist and Webmaster for the Alaska Climate Research Center; **Jan Dalrymple**, Administrative Assistant in the Director's Office; **Guy Tytgat**, Geophysicist with the Alaska Volcano Observatory, and **Rose Watabe**, GeoData Center Supervisor. Community Service awards were given to Operations Man-

ager **Robert Grove** and Photo-Graphics Center Supervisor **Evelyn Trabant**.



Bob Grove, Evelyn Trabant, Jan Curtis, Orion Lawlor

Assistant Operations Manager **Penelope Noecker** and Accounting Technician **Ann Trent** both received Thrifty Nickel awards, which are given to employees whose cost-cutting efforts result in substantial savings for the Institute.

Outstanding Student awards have been given to Alaska Synthetic Aperture Radar Facility Student Assistant **Orion Lawlor**, and to **Erin Pacher**, a Student Assistant who worked in the Information Office.

EMERITUS STATUS

Former Professors of Geophysics **Tom Hallinan**, **Bill Stringer**, **Gunter Weller**, **Gene Wescott**, and **Tom Osterkamp** received the rank of Professor Emeritus from the University of Alaska. Emeritus is a status given to retirees who served UA with distinction in teaching and research. The status is bestowed to symbolize the university's desire to maintain a relationship with outgoing faculty.

RETIREMENTS

Sue Ann Bowling, who recently retired as an Assistant Professor of Geophysics, received her A.B. (1963) from Radcliffe College, and her M.S. (1967) and Ph.D. (1970) from the University of Alaska. After joining the Geophysical Institute in 1970, she became involved in studying circulation, climate and paleoclimate in Alaska and human influences on climate, solar-weather relationships, and applied research in air pollution. Bowling wrote the Alaska Science Forum column for a year and a half, and taught science courses for nonscientists, including "Dynamic Meteorology," "Introduction to Space

Science," and "Geophysics for Nonscientists." Bowling also taught introductory courses on the weather.

Neal Brown, who retired as a Research Assistant Professor of Physics, continues to maintain a professional relationship with the Geophysical Institute and the University of Alaska Fairbanks. Brown received his B.S. (1961) from Washington State University, and his M.S. (1966) from the University of Alaska. He participated in various upper atmospheric studies involving noctilucent clouds and near-infrared spectroscopy of aurora and airglow. Brown served as director of Poker Flat Research Range from 1971 to 1989. He has a strong interest in teaching and communicating science to the public and to students at the undergraduate level. He developed and ran the Alaska Space Academy for middle-school students.

Tom Hallinan, who retired as a Professor of Geophysics, joined the Institute in 1965 after receiving his B.S.E.E. from Cornell University. He earned his M.S. (1969) and Ph.D. (1976) from the University of Alaska. Hallinan has studied the mechanisms responsible for the characteristic shapes of auroral forms. To study these shapes, he developed systems for auroral imaging using low-light-level television cameras and he has conducted auroral-imaging experiments from rockets and the Space Shuttle.

Tom Osterkamp, who retired as a Professor of Physics, received his B.A. (1962) from Southern Illinois University, and his M.S. (1964) and Ph.D. (1968) from Saint Louis University before joining the Institute in 1968. He has researched the physics of snow, ice and permafrost, particularly the scientific aspects of environmental, engineering, and scientific problems. Osterkamp taught undergraduate and graduate physics courses as well as specialty courses on the physics of ice, snow, sea ice, and permafrost.

Neta Stilkey recently retired as Business Office Manager after 31 years of service. Stilkey was hired at the Institute in 1966 as a data processing assistant. Within the year, she worked with archives and mail, then moved to the GI Business Office as an accounts payable clerk. During the next five years, she worked on purchasing, payroll, and property before being promoted to Assistant Manager of the Business Office. She was promoted to Manager in the early 1970s, the position she

held until she retired. She now lives in Fairbanks for most of the year near her parents, children, and grandchildren. In the summer, she and her husband spend time on their boat.

Bill Stringer, who retired as an Associate Professor of Geophysics, received an M.S. (1966) and a Ph.D. (1971) at the University of Alaska. He joined the Institute in 1967. Stringer conducted a comprehensive characterization of Alaska nearshore ice conditions for the Outer Continental Shelf Environmental Assessment Program. To increase public understanding of science, Stringer produced movies and exhibits and conducted community college courses. His community activities include six years as a member of the Fairbanks North Star Borough Assembly.

Gunter Weller recently retired as a Professor of Geophysics after 29 years of service. He received his B.S. (1962), an M.S. (1964), and a Ph.D. (1968) from the University of Melbourne, Australia. While at the Geophysical Institute, Weller served as program manager of the National Science Foundation's polar programs in meteorology from 1972-1974; Project Manager of NOAA-BLM's Outer Continental Shelf Assessment Program in the Arctic from 1975-1982; and Project Director of the NASA-UAF Alaska SAR Facility from 1986-1993. Weller is now the Director of UAF's Center for Global Change and Arctic System Research and the NOAA-UA Cooperative Institute for Arctic Research (CIFAR). He was the chairman of the National Academy's Polar Research Board from 1985-1990.

Gene Wescott retired as a Professor of Geophysics after 39 years of service. He received his M.S. (1960) and his Ph.D. (1964) at the University of Alaska. After joining the Institute in 1958, he investigated telluric currents and a wide range of magnetically conjugate geophysical phenomena. Wescott initiated and carried out a program of rocket and satellite chemical releases to investigate the electrodynamics of the aurora and the magnetosphere and to perform plasma physics experiments. He was prominent in the evaluation of geothermal resources of Alaska using geophysical techniques. With Davis Sentman, he has investigated optical flashes in the upper atmosphere. These flashes, known as red sprites and blue jets, are believed to be associated with lightning.

Aurora Alive

The Aurora Alive Science Enrichment Program teaches the physics of the aurora to Alaska Native students in rural areas.

The project, funded by the U.S. Department of Education through a three-year grant awarded to the Institute's Information Office, involves the creation of an educational, interactive CD-ROM and a series of associated classroom lessons. In-

stitute Director Syun Akasofu and Associate Director Roger Smith are the scientific advisors for the project, which graphically depicts the physics of the aurora in terms middle-school students can understand.

Alaska Native elders, teachers, and students also are involved with the creation of Aurora Alive, which is illustrated in part by artwork donated by Artist Rie Muñoz.

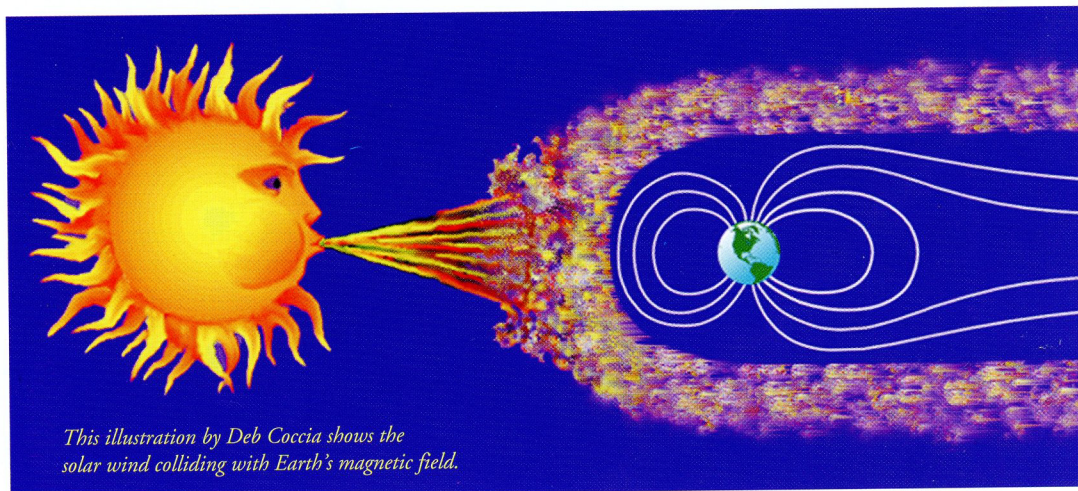
Aurora Alive is being field tested in the small, rural village of Noatak, Alaska, an isolated community located about 35 miles north of the Arctic Circle.

The program is composed of a series of educational units that provide scaffolding for the students' understanding of physics.

Each Aurora Alive unit meets National Science Standards, Alaska Content Standards, and, when possible, Alaska Standards for Culturally Responsive Schools.

Aurora Alive classroom lessons provide an opportunity for hands-on activities that encourage cooperative learning and community participation.

The CD-ROM promotes individual learning that can proceed at a pace set by each student and provides graphics and interactive elements that can help students visualize difficult scientific concepts and theories.



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