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Spurr Spouts Again, But AVO Members Prepared

An airline pilot flying over a chain of Cook Inlet volcanoes was the first to report seeing a plume rising above Mount Spurr just before 4 p.m. on Tuesday, August 18. Research Professor Steve McNutt reacted with mixed emotions when he heard the news a few moments later. Was it another false alarm, or was Mount Spurr really going to erupt for the second time in one summer?

McNutt, acting coordinating scientist for the Alaska Volcano Observatory, had been receiving calls about similar sightings on a near-daily basis since the volcano erupted on June 27 for the first time in 39 years. Most sightings turned out to be clouds or harmless plumes of steam released when small amounts of hot gas escaped from the volcano.

McNutt stepped outside his office on the third floor of the Geophysical Institute to check the helicorders, instruments that measure seismic activity. The silver arm above one of the helicorder drums flickered, and black ink scribbled a jagged line on the white paper beneath it. The line indicated a weak volcanic signal that lasted for 16 minutes, then stopped abruptly. McNutt called the U.S. Geological Survey (USGS) office in Anchorage to contact Tina Neal, AVO's acting scientist in charge. After analyzing the data and consulting with their colleagues, they decided to stay at code green, meaning they considered the volcano to be in its normal dormant state.

McNutt watched the signal on the helicorder drum for any sign of elevated seismic activity. Ten minutes later, he received notification the plume had appeared on radar systems at the National Weather Service. Then, two more pilots reported the plume was becoming dark, indicating ash, not just steam, was probably ejecting from the volcano.

At 4:25 p.m., McNutt and Neal went to code yellow, meaning they considered the volcano to be restless. All such changes in status are immediately reported to the FAA, the Alaska Division of Emergency Services, the United States Air Force, AVO scientists in Anchorage and in Fairbanks, the National Weather Service, the Alaska Division of Geological and Geophysical Surveys (ADGGS), the western regional headquarters for USGS in California, Governor Hickel's office, Fairbanks International Airport, Fort Wainwright Emergency Operations, the Alaska Synthetic Aperture Radar Facility, and Geophysical Institute Director Syun Akasofu.

At 4:42 p.m., a seismic signal indicated the main phase of the eruption had begun. McNutt and Neal went to code orange, meaning they concurred that a small eruption was starting with plumes not likely to rise above 25,000 feet. The status change was reported around the state. Minutes later, another pilot reported seeing the plume reach 35,000 feet. At 4:58 p.m., McNutt and Neal changed the status again to the highest possible alert—code red, meaning they wanted to advise all concerned that Mount Spurr was probably spewing out large clouds of ash with plumes rising above 25,000 feet. The main phase of the eruption lasted four hours and 31 minutes, releasing more than 100 million cubic meters of ash into the atmosphere.

Seconds after they issued the alert, McNutt and other AVO staff were besieged

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STEAM PLUME—*Hot gas escaping from Mount Spurr when the volcano is quiet can confuse onlookers into thinking an eruption is occurring. Scientists rely on a variety of seismic instruments to verify eruptions. The steam plume emitting from Mount Spurr (above) was photographed at 5 p.m. on July 1, after the volcano erupted for the first time in 39 years on June 27.*

Alaska's Great Gorge Deeper Than Grand Canyon

What may be the deepest gorge in North America, and possibly the world, was measured successfully for the first time this summer by scientists from the Geophysical Institute.

The "Great Gorge," located on the south side of Mount McKinley, was found to be nearly 9000 feet deep, making it deeper than the steepest valleys in the Grand Canyon and in Yosemite National Park. The measurement includes the ice of the Ruth Glacier, which fills the bottom of the gorge, combined with the height of the vertical walls surrounding it.



***HISTORIC FLIGHT**- Bradford Washburn took this photo of the Ruth Glacier during a flight around and over Mount McKinley on August 9, 1937. The view of the 40-mile-long glacier and the Great Gorge through which it flows so impressed him that Washburn became determined to find out more about the area. Many of his questions about the gorge and glacier were answered 55 years later by a research team from the Geophysical Institute.*

The 40-mile-long Ruth Glacier drains the southern slopes of Mount McKinley as it flows through the granite-walled Great Gorge. Impressive mountains such as Moose's Tooth, Mount Dickey, the Shield, and Rooster Comb rise up along its sides. Most of the Ruth Glacier is located within Denali National Park and Preserve.

Commissioned by Bradford Washburn, honorary director of the Boston Museum of Science, researchers set out to find the bottom of the gorge two years ago. First, they tried to determine the total depth of the gorge by measuring the thickness of the Ruth Glacier with conventional ice radar instruments. By sending radio signals into the ice and receiving echoes off the bottom, these instruments have little trouble measuring ice depths of up to 2000 feet. The problem was the gorge is so deep and narrow that the radio signals bouncing off the bottom were too weak. They got lost among the jumble of noise created by the waves bouncing off the side walls.

This summer, the scientists tried again. Led by Associate Professor Keith Echelmeyer, a crew including GI graduate Ted Clarke, GI Research Assistant Keri Petersen, GI Glaciology Technician Chris Larsen, and Field Assistant Kent Swanson returned to the gorge with sticks of dynamite and 12 receiving units called geophones, basic tools of seismic expeditions. The researchers dug holes in the ice, planted the geophones in a widespread array and set off dynamite explosions, repeated several times. These dull thuds sent sound waves moving through the ice to the bottom, then bouncing back to be picked up and timed by the geophones.

By analyzing the return signals, the scientists were able to determine the depth and the shape of the gorge and the glacier. The 9000-foot-deep gorge is U-shaped and less than a mile wide at the top, and the ice contained within it is more than 3800 feet thick.

Washburn, who has mapped both Mount McKinley and Mount Everest, said he's been waiting for 55 years to find out the depth of the Great Gorge because he suspected it would be among the deepest gorges in the world.

"Every flake of snow that falls on the southeastern flanks of Mount McKinley pours downward and is squeezed through that mile-wide gorge," Washburn said during a recent telephone interview from Boston. "I knew the gorge had to be very, very, very deep."

Washburn has done extensive studies on the Muldrow Glacier on Mount McKinley and was responsible for designing a detailed large-scale map of the area in 1960. During his studies, Washburn became fascinated with the nearby Ruth Glacier.

"On August 9, 1937, I made a photographic flight around and over Mount McKinley," Washburn said. "It was on that flight that I got my first glimpse of the Great Gorge and it was an experience I'll never forget. The Ruth is McKinley's most spectacular glacier and the wilderness through which it flows is the most dramatic in North America."

Washburn hopes others will finance more studies on the Ruth Glacier above and below the Great Gorge to record the depths of snow that accumulate at the head of the glacier and to determine the rate at which the glacier melts and flows. This summer, Echelmeyer measured how fast the glacier moved through the Great Gorge. Using a satellite-based surveying method, he found the ice moved an average speed of 3.3 feet per day, which is relatively fast for a glacier. ✉

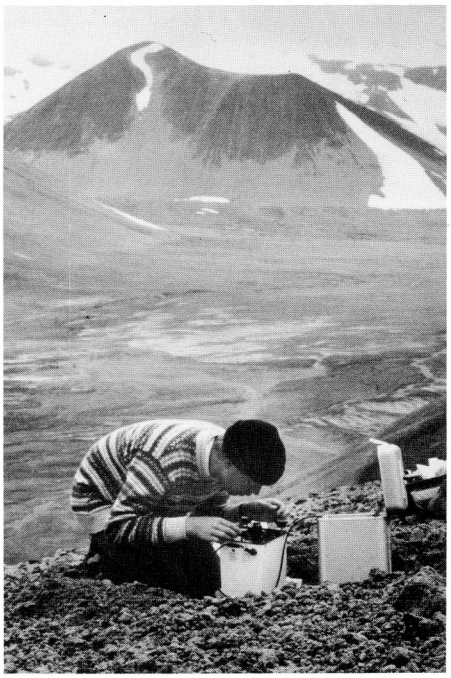
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Researchers Hope to Drill into Massive Volcano in Katmai



JOHN EICHELBERGER

NOVARUPTA'S VENT—*Andy Goodliffe, a GI graduate student, measures gravity in Katmai National Park. His work helped locate the Novarupta vent, which lies buried under layers of its own ash. The eruption was the largest on earth this century.*

Blocks of material ejected in the late stages of the largest and most explosive eruption of the 20th century were analyzed this summer by researchers from the Geophysical Institute.

Examined in the study were rocks shot out from deep within the throat of Novarupta, the volcano that erupted for 60 hours in June 1912 in the heart of what is now Katmai National Park and Preserve. Considered to be one of the dozen largest eruptions in recorded history, the colossal explosion spewed out about seven cubic miles of material and devastated a surrounding area of about 50 square miles. That still desolate area, now called the Valley of Ten Thousand Smokes, was buried under as much as 700 feet of ash.

Scientists have been conducting research within Katmai National Park for years to learn more about that relatively recent, massive, one-time eruption. This summer, researchers studied material ejected late in the eruption to find out more about what kinds of rocks lie inside the volcano and about what kinds of gases were released during the 1912 eruption. Gases are the propelling force behind any volcanic eruption. Those released quickly drive the eruption and those released more slowly are involved with the transport of metals leading to the development of ore deposits.

Studying rocks ejected onto the surface from deep within the volcano is the closest scientists have come to examining the material that now fills the giant hole under Novarupta. But a consortium of 18 government institutions and universities headed by GI Professor of Volcanology John Eichelberger wants to probe deeper. Starting in 1994, scientists hope to spend two summers drilling into the throat of Novarupta to pull out 8000 feet of cylindrical, cooled rock samples. The $10 million drilling proposal will be funded by the Department of Energy, the National Science Foundation, and the United States Geological Survey.

The consortium recently asked the National Park Service for permission to set up two 50-foot-tall drilling rigs and a temporary camp that would house about 20 scientists, drillers, and engineers during the summers of 1994 and 1995. National Park Service officials are directing the development of an environmental impact statement on the project now and will give the consortium an answer next year.

Scientists in the consortium are confident their research will leave no scar in the wilderness area. "We will not leave any evidence that we have been there," Eichelberger said. "We believe that everything we do can be remediated."

No group has drilled into this kind of volcano before because the technology for boring into such a hot area and the government backing for doing so were not available until recently, Eichelberger said.

According to a special panel within the National Academy of Sciences, Novarupta is an exceptional place to conduct such research because the volcano is big and young, and it formed during a single event within a geologically simple setting.

Scientists expect that studying the cores pulled from Novarupta will give them new understanding of how and why volcanoes erupt. Such information will help volcanologists better predict eruptions, understand more clearly how mineral deposits are formed as a result of volcanic activity, and learn more about the tremendous geothermal energy beneath the earth.

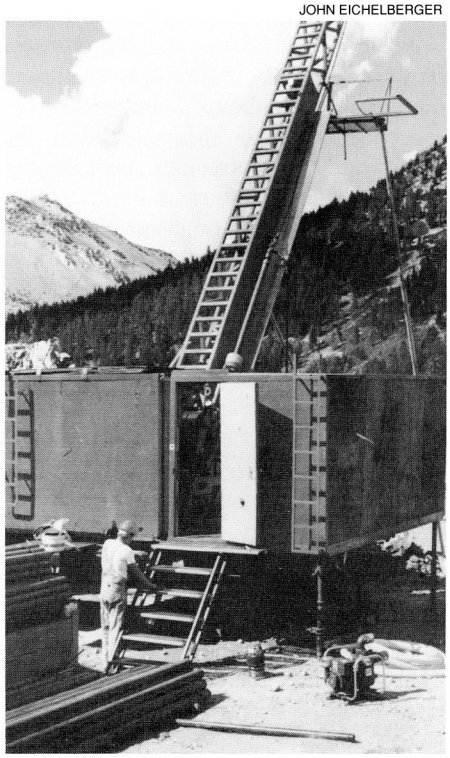
"There is a general feeling that there are a whole host of questions concerning the structure, composition, and condition of the earth's crust that we need to explore in greater depth," Eichelberger said. "By now, we have learned most of what we are going to learn studying the earth's surface. The logical next step is to start going down."

A federal desire to probe deep into the earth led several years ago to the implementation of the Continental Scientific Drilling Program, a federal program that promotes advances in drilling technology as well as advances in scientific inquiry.

"With this program, we'll be pushing our ability to penetrate different environments, both in temperature and in depth," Eichelberger said. "In the future, as natural resources become more scarce, we'll need to rely on new drilling technologies."

During the Novarupta project, drilling rigs will bore into material nearing temperatures half way to the melting point of rock. Similar scientifically motivated drilling projects also are occurring in other countries, especially Russia, Germany, and Japan, Eichelberger said. ✉

JOHN EICHELBERGER



DRILLING RIG—*The diamond core drilling rig pictured above is similar to the type scientists hope to use to pull up 8000 feet of cylindrical cooled rock samples from the throat of Novarupta, starting in the summer of 1994. Studying the cores should reveal new information about how and why volcanoes erupt.*

Synthetic Aperture Radar—What's That?

How can synthetic aperture radar be explained to nonscientists? This problem often confronts members of the Alaska Synthetic Aperture Radar Facility (ASF) when diverse groups from grammar-school students to touring politicians want to visit and understand ASF at the Geophysical Institute. The analogies below might be called the eavesdropper's definition of synthetic aperture radar because they come from overhearing many valiant attempts by the technically expert to make this subject understandable to the technologically uninformed.

Consider a simple flash camera. For this device to produce an image, a certain sequence needs to occur. A flash emits visible light; the light illumines the object to be depicted; the image of the illuminated object is captured by film—the light-sensitive recording medium in the camera. Light reaches the film through the "aperture," an opening in the camera body.

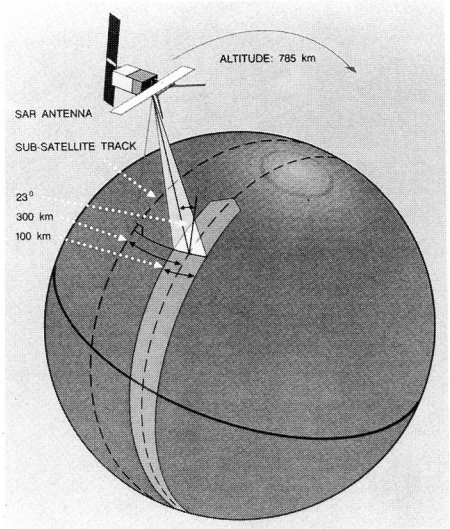
Keeping that camera in mind, consider a typical radar, the kind used on commercial fishing vessels off the coasts of Alaska. Instead of emitting or generating a pulse of light, the radar generates a pulse of radio waves. The radio waves go forth as light waves do from a flash bulb; they bounce off the object to be depicted and return to the radar, where they are captured by the receiving antenna. The antenna is the radar's aperture, its opening on the world. The information returned by the radio waves is displayed on a screen, which indicates the radar has detected an object, such as another boat hidden by fog or darkness, for example.

Put the radar in an earth-orbiting satellite, give it enough power to send radio-wave pulses to the planet below, and you'll have a device capable of producing images of what the radar detected, such as images of sea ice or lakes or vast icebergs hidden by fog, clouds, or darkness. Water droplets in fog and clouds are as transparent to radio waves of the proper frequency as window glass is to light waves of visible-spectrum frequency. That is why SAR satellites can gather data in conditions where optical sensors would be useless.

Once more, consider the images captured by a camera. As many snapshot albums illustrate, cameras provide images of a pretty small area. For example, your eye may take in the whole party, but your camera recorded only the top half of the cake and the bottom half of the birthday child. If the photographer sweeps around the room with an ordinary camera in an attempt to catch more of the scene, the film will record nothing but a blur. It takes a special camera designed to capture panoramas, a camera equipped with synchronized mechanisms so the camera and the film-advance gears move in coordination. It's as if the camera's aperture were a huge slit rather than a tiny opening, or a whole chain of tiny openings strung together. That's what's needed to record images of whole landscapes (or whole parties).

Look up the word "synthetic" in the dictionary and you'll find its roots lie in a Greek word meaning "put together." The panoramic camera uses, in the truest sense of the word, a synthetic aperture. By keeping everything moving in the proper way, it creates the equivalent of a far larger aperture.

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SAR SWATH—*The diagram above illustrates the ground track, or swath, covered by the SAR instruments aboard the European Remote Sensing satellite (ERS-1). SAR obtains strips of high-resolution imagery 100 km wide to the right of the satellite track. The antenna is aligned parallel with the satellite orbit to direct a narrow radar beam sideways and downwards onto the earth's surface over the 100 km swath. Imagery is built up from the strength of the return signals.*

Satellite-borne radars monitored at ASF are synthetic aperture radars in this sense also. Unlike the simple fishing-boat radars, SAR antennas are designed to take advantage of their satellite's movement.

As the satellite moves over the earth's surface at about five miles per second, it transmits and digitally receives back a return signal every four feet, which is then transmitted to ASF. The movement enables the small receiving antenna on board the European Remote Sensing satellite (ERS-1), to receive so much data about the earth over which it passes that it's as if the antenna were actually the size of a football field. Those effectively huge antennas give SARs very high resolution, so they can produce images far more detailed than the crude blips on the radar screens of fishing boats. ✉



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SEA ICE—*Freshly formed sea ice is shown in the SAR image at left, eddying around Wales Island in Committee Bay in the Canadian High Arctic. SAR data are received at the Alaska Synthetic Aperture Radar Facility (ASF) in the Geophysical Institute, then processed into images and other information that is used by scientists around the world. The data used to create this image were sent to ASF by the ERS-1 satellite.*

ASF Aids Ships at Sea, Polar Scientists, Global Climate Change Research, and More

A Japanese ship traversing the Northwest Passage late this summer got help through ice-laden waters from satellite data processed at the Alaska Synthetic Aperture Radar Facility (ASF) within the Geophysical Institute. The *Frontier Spirit* left Greenland on August 18 and arrived in Nome carrying 120 passengers on September 9.

The trip was the first the *Frontier Spirit* had taken through the Northwest Passage linking the Atlantic and Pacific oceans. Owned by the Tokyo-based NYK company, the luxury liner was previously used for cruises along the Antarctic Peninsula.

As a result of their arctic voyage, French scientists aboard the ship hope to find better ways to predict ice motion for navigational purposes with the eventual goal of being able to design a polar oceanographic research vessel capable of being frozen in the ice pack for two years or more, according to a written statement by Pierre Sauvadet, a polar explorer who made the trip.

Data about the sea ice and open water along the ship's route through the Northwest Passage were obtained at ASF from a satellite orbiting about 490 miles above the earth, launched by the European Space Agency last year. Data received at ASF from that European Remote Sensing (ERS-1) satellite were analyzed and interpreted by ASF Chief Scientist and Professor of Geophysics Willy Weeks before information was faxed to the ship.

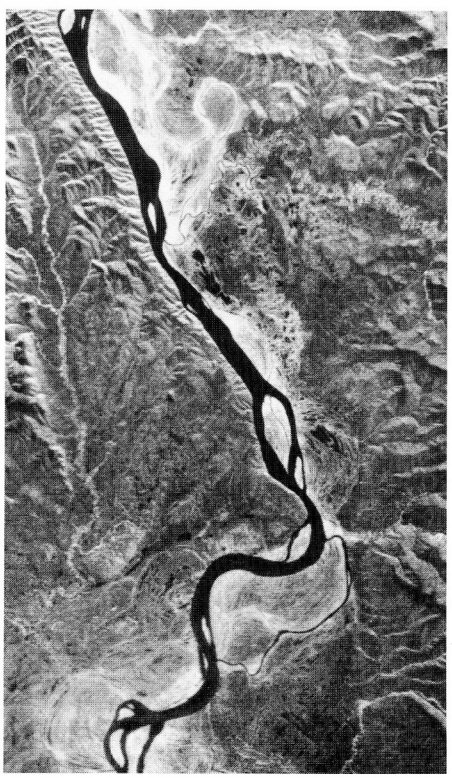
ERS-1 data processed at ASF also were used to help a French ship successfully navigate through the Northeast Passage last year. That vessel was the first non-Russian ship to transit the polar ice pack in 40 years.

Assisting a shipload of explorers has been one of ASF's more romantic tasks, but by no means its primary one. Scientists at the facility are involved in research on topics ranging from sea ice studies to mineral exploration. ASF is the only facility in the United States set up to receive and process data from the ERS-1 satellite and from the Japanese Earth Resources Satellite (JERS-1), which orbits about 355 miles above the earth.

Data from these foreign satellites received at ASF are turned into high-resolution radar images, which resemble photographs of the earth from space that are so detailed even a ship's wake is discernible. The images contain valuable information on the distribution of (and changes in) the earth's natural features, such as sea ice, glaciers, rivers, lakes, mountain ranges, and vegetation. Color-enhanced images illustrate with dramatic clarity sudden changes on the earth's surface, such as ash plumes from erupting volcanoes or oil spills in the ocean.

The images produced at ASF are available to scientists worldwide and already have been used for a variety of purposes, including global climate change research. The images are particularly valuable because they enable scientists (or explorers) to monitor the earth's surface and sea ice continuously through bad weather and other conditions that previously have prevented scientists from conducting research in remote areas of the Arctic.

ERS-1 and JERS-1 both carry synthetic aperture radar (SAR) designed to scan large areas of the earth's surface through all kinds of weather—darkness, fog, snow, rain, and clouds—conditions that limit the usefulness of many other kinds of satellite-borne remote sensing systems.



YUKON RIVER—*The Yukon River is shown above in one of the early test images from the Japanese Earth Resources Satellite (JERS-1). The 30-by-40-mile area covered in the image includes Fish Island, Yuki Island, Melozi Island, the village site of Ruby, and numerous oxbows and meanders of Yuki River and Ruby Slough tributaries (image received and processed by ASF).*

"The advantage of conducting research using SAR images is that you can keep track of what's going on all the time," said Weeks, who studies sea ice in areas often obscured by clouds and darkness. "It is easy to obtain a very biased view of reality if one can only examine the ice on a few clear days."

Geophysical Institute Research Associate Professor Martin Jeffries uses SAR images to study ice shelves located along the coast of Ellesmere Island, the northernmost island in the Canadian Arctic. These large thick ice masses have been disintegrating over the past 100 years. A steady stream of SAR images will help determine where and at what speed the breakup is occurring, and if the disintegration process is related to climate warming.

Before SAR, sea-ice scientists were forced to rely on a combination of spotty visual and infrared imagery and oversimplified computer-generated models that showed the polar ice pack as a huge, uniform white mass with little definition. Using SAR imagery, scientists can detect many features within the ice, such as individual ice floes, pressure ridges, and open or newly refrozen leads. SAR images also can be used to pinpoint icebergs or large ice islands, which could damage offshore oil facilities as well as ships at sea.

While the ERS-1 data concentrates on oceanic phenomena, JERS-1 data is designed to be particularly useful in geologic research and mineral exploration. ASF began receiving data from ERS-1 shortly after it was launched in July 1991, and has been getting data from JERS-1 since May 1992. So much data has been pouring in since then that the station went from a 16-hour to a 24-hour operation in June. ASF expects to receive data from up to six JERS-1 and eight ERS-1 satellite passes daily for the next three years. ASF also is scheduled to receive data from RADARSAT, a Canadian satellite scheduled to be launched in 1995.

The National Aeronautics and Space Administration selected the Geophysical Institute as the sole site for the U.S. satellite-borne SAR receiving station partly because the institute's northern location makes it possible for ASF to receive data from numerous passes of polar-orbiting satellites and partly because the Geophysical Institute can supply ASF with trained scientific and engineering personnel. ASF's scientific system was designed by the Jet Propulsion Laboratory of the California Institute of Technology. ✉

Spurr Spouts Again

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with phone calls from news agencies, airlines, emergency organizations, state troopers, federal officials, and other concerned citizens. The inquiries increased when it became apparent that the 11-mile-high ash plume was going to blow directly over Anchorage, 80 miles west of the volcano. "Everyone was asking, 'what are we going to do when the ash reaches us?'" McNutt said.

McNutt received a call from the U.S. Coast Guard asking if the ash was thick enough to stall a helicopter they were planning to use to perform a rescue of an overturned boat in Cook Inlet. The Air Force called wondering if the ash would damage or ground their planes. AVO, a cooperative program concerned mainly with monitoring the Cook Inlet volcanoes, has no authority to make recommendations for such important decisions, but they were able to help by giving out detailed scientific information, McNutt said. The agencies involved in AVO are the Geophysical Institute, ADGGS in Fairbanks, and USGS in Anchorage, in Menlo Park, California, and in Vancouver, Washington.

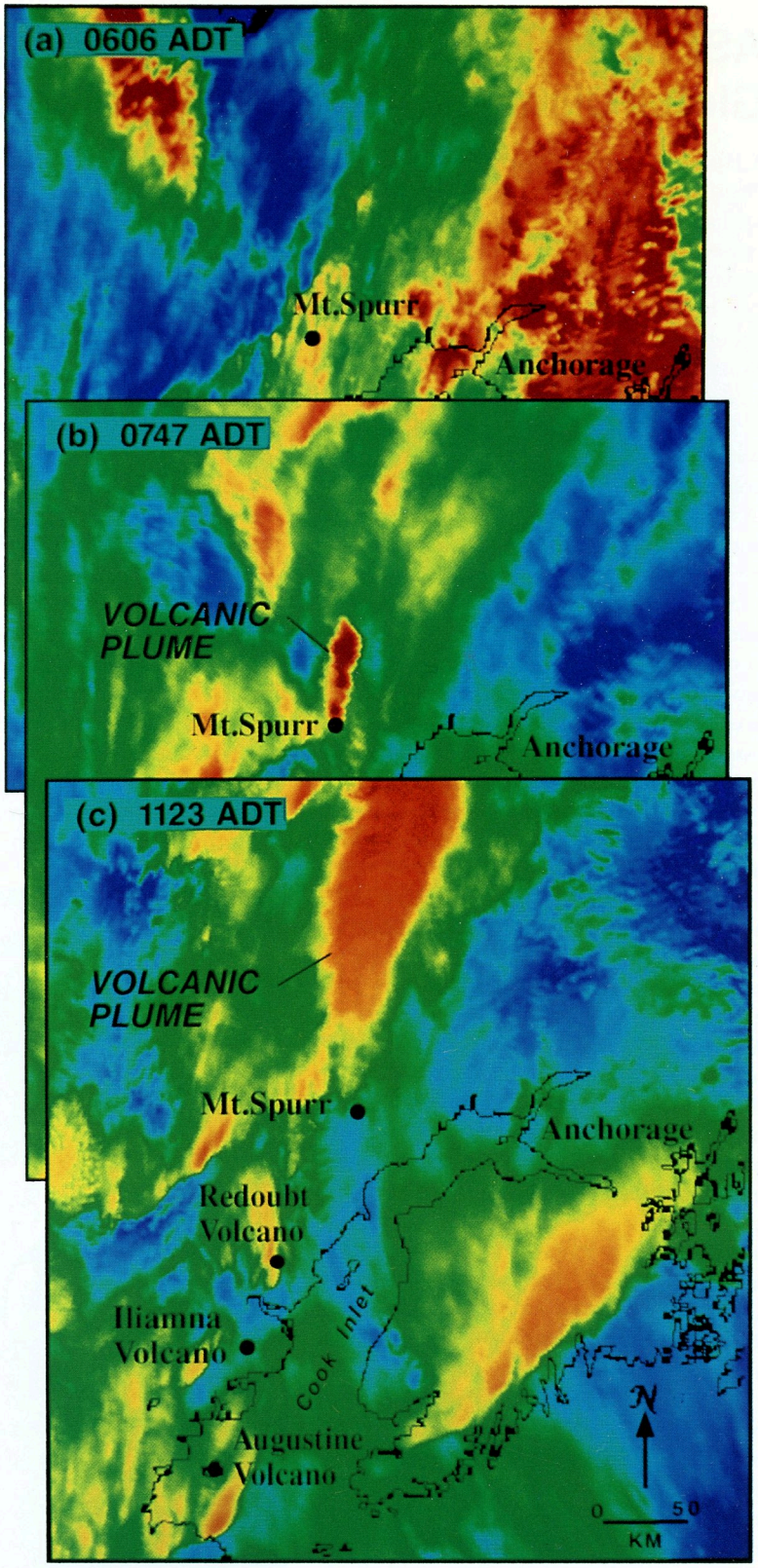
According to statewide newscasts, gray-yellow sand-like ash from Mount Spurr was falling like rain in Anchorage by 8 p.m., causing street lights to flicker and a sulfurous smell to hang in the air. By 8:15 p.m., the Anchorage International Airport was closed, stranding hundreds of tourists. Merrill Field, Lake Hood and Elmendorf Air Force Base also were closed to air traffic. The following day, about a quarter-inch of ash covered Anchorage and light dustings of volcanic ash reached as far away as Yakutat on the eastern edge of the Gulf of Alaska and Kluane Lake in Canada's Yukon Territory, 360 miles east of Anchorage.

McNutt and Neal changed the status back to code orange at 9:30 p.m. on August 18, then to code yellow the following day, but AVO remained on 24-hour alert for two weeks after the eruption. The volcano was quiet for nearly a month after that, until it erupted again on September 16.

With all this activity, AVO scientists have become accustomed to keeping close watch on Mount Spurr, and they've had plenty of practice. They'd been monitoring it with a suspicious eye for nearly a year before it rumbled to life after a 39-year rest on June 27, 1992. Geophysicist John Power, who works in the Geophysical Institute for USGS, was the first to notice a gradual increase in the number of earthquakes under Mount Spurr in August 1991. By February, the number of earthquakes had increased to six per day. In May, the number was up to more than 20 per day. "Those earthquakes dominated our attention all spring," McNutt said. "Although we didn't want to say so publicly, and cause unnecessary alarm, we all started to think something was going to happen."

Power, McNutt, and USGS employee Bob Page wrote an official memo appraising the situation to AVO Scientist in Charge Tom Miller at the beginning of June. "There had been no dramatic sign or anything, but the level of earthquakes had gradually increased enough in number and strength that we thought it was time to say officially we were concerned," McNutt said.

By June 5, AVO scientists had updated telephone lists used to announce official status changes in active volcanoes, upgraded AVO's 24-hour emergency alarm system, and connected more helicorders to seismic stations monitoring Mount Spurr. At the time, nine seismic stations monitored earthquake activity in a 27-kilometer radius around the volcano. The closest station was destroyed during an eruption.



MOUNT SPURR ERUPTS—*Shown above are thermal infrared AVHRR images of the eruption of Mount Spurr on June 27, 1992. The first image was recorded one hour prior to the eruption; the second and third images were recorded 45 minutes and 4.5 hours (respectively) after the start of the eruption (image courtesy of Ken Dean, Shari George, and Deborah Coccia).*

On June 6, the helicorders began to pick up new bursts of volcanic tremor beneath Mount Spurr, lasting between one and 10 minutes. During the next three weeks, up to 24 of these new tremors were recorded daily.

On June 24, the earthquakes were accompanied by two episodes of volcanic tremor lasting nearly three hours, recorded 12 hours apart. Then, dramatic seismic activity stopped until just after noon on June 26, when a strong volcanic signal started that would eventually last for 15 hours.

Four hours after that signal started, AVO went to code yellow alert. That afternoon, Geologist Chris Nye, who works in the Geophysical Institute for ADGGS, observed the volcano from a helicopter so he could report any sudden or unusual changes in the area. He was startled to discover that a lake in the crater of the volcano was half empty—a lake that had been full for more than 30 years.

News agencies were alerted to the imminent possibility of eruption and AVO technicians began monitoring the helicorders around the clock. At 4 a.m. on June 27, AVO Geophysicist Guy Tytgat noticed an earthquake swarm, a large number of small earthquakes, under Mount Spurr. At 4:30 a.m., he alerted other AVO members in Fairbanks, Anchorage, and California that trouble was brewing. Between 5 a.m. and 7 a.m., the rate of earthquakes increased to one every two minutes. At 7:04 a.m., a strong tremor began that looked as if it was signaling the beginning of an eruption.

At 7:16 a.m., McNutt, State Seismologist John Davies, and AVO Chief Scientist Tom Miller decided to go to code orange. Five minutes after they'd sent the alert around the state, they received a pilot report verifying the ash plume had reached 17,000 feet. Prior to that, clouds had obscured visual signs of the eruption. Another pilot report confirmed the ash cloud had reached 30,000 feet and AVO went to code red. The eruption lasted four hours and 15 minutes, spewing out 50 million cubic meters of ash, which blew north over Mount McKinley.

Earthquake activity decreased significantly after the eruption, but AVO scientists continued to monitor the volcano closely during August. Those who helped keep 24-hour watch in the Geophysical Institute during orange and red alerts were Research Assistants Vicki McConnell, Dominique Gillard and Michelle Harbin, Data Processing Assistant Gina Cruse, Geophysicist Guy Tytgat, and Student Assistant Cere Davis, all with the Geophysical Institute, Geologist Art Jolly and Physical Science Technician Scott Stihler with the United States Geological Survey, and Geologist Deanne Pinney with the Alaska Division of Geological and Geophysical Surveys. ✉



AIR DROP— *GI Research Professor Steve McNutt drops a geobuoy on Mount Augustine this summer. The devices were tested on Mount Augustine and Mount Spurr to see if they could survive the air drop in good enough shape to transmit useful information about earthquakes occurring within and around the volcanoes to AVO laboratories in Anchorage and Fairbanks. Scientists hope geobuoys will eventually be used to monitor remote, hard-to-reach volcanoes in the Aleutian Islands (photo courtesy of Tom Murray, USGS).*

Ozone-destroyers Found in Arctic Skies

An "ozone hole" federal researchers feared might develop over the Arctic this summer has not materialized, according to Geophysical Institute scientists.

Concern there would be severe reductions in the ozone layer above the Arctic began after scientists with the National Aeronautics and Space Administration discovered the highest levels of ozone-destroying chemicals ever measured in the skies above the northern hemisphere. The levels were far higher even than those recorded above Antarctica, where an ozone hole already is well established. The discovery was made during a six-month, federally-financed study that gathered data from satellite transmissions and airplane observations.

Ozone forms a protective layer around the earth between 14 and 25 kilometers high that prevents damaging amounts of the sun's ultraviolet light from reaching the ground. The term "ozone hole" is used to describe a 20 to 50 percent reduction in the concentration of ozone above a certain location.

Monitoring the ozone layer above Interior skies was critical this spring and summer because the returning sunlight could have started the chemical reactions needed to deplete the ozone layer. Chlorine monoxide, the main ozone-destroying chemical identified by the NASA scientists, needs both sunlight and cooler temperatures for the crucial reactions to occur.

So far, ozone levels above the Arctic seem to be normal for this time of year, but scientists are watching carefully to make sure that condition doesn't change, according to Dan Jaffe, assistant professor of chemistry at the Geophysical Institute.

Scientists measure the number of ozone molecules found in a column between the ground and the sun several times each week on a specialized instrument called a Dobson spectrometer, located at Poker Flat Research Range.

Losses in ozone can cause an increase in the risk of skin cancer, cataract-induced blindness and immune system damage. It also can cause crop damage and the death of phytoplankton in the ocean, a critical part of the food chain. Long term ozone losses of between two and six percent have been observed in the northern hemisphere over the last 15 years, but such a small reduction does not bring about an increased health risk locally because the angle of the sun in the Interior is too low to allow much ultraviolet radiation to reach the earth, according to Knut Stamnes, professor of physics. ✉

Rocket Soars above Night-Shining Clouds

A 48-foot-tall rocket was successfully launched from Poker Flat Research Range this summer to study "noctilucent" (or night-shining) clouds believed to be indicators of global climate warming. The rocket, which went up at 5:36 a.m. on Friday, July 24, was the only major launch this summer from Poker Flat, a 5132-acre site about 30 miles northeast of Fairbanks.

The rocket blasted off shortly after Professor William Sharp of the University of Michigan, principal investigator for the mission, received a satellite report indicating that noctilucent clouds were covering the skies overhead and the finding was verified by a laser beam from a light detection instrument on range.

Noctilucent clouds are difficult to see with the naked eye because they appear in thin, pearly-white bands about 50 miles above the earth, seven times higher than thunderheads. Scientists believe noctilucent clouds are composed of frozen water, which can't form at high altitudes without assistance. That assistance appears to come from methane, a "greenhouse gas" even more effective at trapping heat and holding it close to the earth than carbon dioxide, the most commonly named culprit in global climate studies.

The number of noctilucent clouds in the atmosphere has increased dramatically over the past 10 years and many scientists attribute that increase to a global increase in methane, released into the atmosphere primarily through garbage dumps, cattle pastures, and rice farming. The clouds appear over Fairbanks only during late July and early August, according to Geophysical Institute Assistant Professor Neal Brown.

Noctilucent clouds above Fairbanks were examined from a height of 145 miles by the 11 instruments in Sharp's rocket payload. One of the instruments used sunlight scattering off the clouds as a basis for determining the size and number of particles composing them. Other instruments in the rocket payload determined the temperature and the atomic and molecular make up of the surrounding atmosphere as well as variations in the magnetic field.

Data from the nine-minute flight was sent by radio transmission to the ground, where it was stored on magnetic tape for examination later. The rocket payload was recovered from the foothills of the Brooks Range about 20 miles east of Chandalar Lake. Many of the instruments will be used again in future noctilucent cloud research, Sharp said.

Two eight-foot-tall rockets were launched before and after Sharp's mission so scientists could obtain baseline data on atmospheric conditions. Sharp's rocket was supported by personnel from NASA's Wallops Island Flight Facility and by researchers with the Geophysical Institute. Currently, the $1.5 million annual cost of range operations is funded by the National Aeronautics and Space Administration.

GENEZARET BARRON



ROCKET LAUNCH—*A 48-foot rocket was successfully launched from Poker Flat Research Range this summer to study clouds believed to be indicators of global climate warming.*

Student Rocket Launches Instruments into the Atmosphere

A rocket assembled by University of Alaska Fairbanks students was successfully launched at 3:39 a.m. Friday, July 17. The six-foot-tall 70-pound rocket was the first to carry student-designed instruments into the atmosphere. The rocket shot up 15,000 feet, carrying four instruments in the payload—two that measured the acceleration and stability of the rocket during ascent, and two that recorded atmospheric temperature and pressure on the way down.

The rocket payload descended under parachute to the ground about a mile downrange from the launch area, just over the Chatanika River. Personnel at Poker Flat tracked the descending payload with radar while students followed it with a receiver and antenna they built themselves. The project was funded with a $50,000 grant from the federally funded Alaska Space Grant Program. ✉

Cloud Researchers Need 20,000 Square Miles on North Slope

Scientists searched for a 20,000-square-mile area on the North Slope this summer to conduct research on how clouds and solar radiation in the Arctic affect global climate change.

The North Slope site will be one of five field laboratories selected from around the world by the U.S. Department of Energy to conduct long-term, sophisticated research into how clouds alter the earth's climate.

Federal officials appointed Geophysical Institute Physics Professor Knut Stamnes to oversee the scientific details and the daily operations of the proposed 10-year, $10-million project on the North Slope, scheduled to begin in 1994.

The project, officially known as the Atmospheric Radiation Measurement (ARM) Program, consists of an array of instruments designed to measure all aspects of climate. Most of the instruments will be housed in one primary station to be built in the center of a 200-by-200-mile research area. The primary station will be supported by instruments within four smaller stations on the borders of the research area and within auxiliary units spread throughout the test site.

From this network of arctic stations, scientists want to measure the atmosphere's heat balance, which is determined by the amount of solar energy coming down to the earth from space versus the amount of energy being radiated back to space from the earth. Climate warming or chilling occurs when there is a long-term imbalance in this dynamic equation.

The research area needs to be large, diverse, and remote so that the instruments within each station will be able to measure a variety of cloud types, temperatures, humidity, and other atmospheric conditions typical of the Arctic.

Three possible 20,000-square-mile areas on the North Slope suitable for the ARM program will be chosen this summer. These options will be reviewed by a federal committee, then undergo environmental assessments to make sure the buildings and the instruments they contain will not disturb life in nearby communities or disrupt wildlife migration.

No such problems are expected since the buildings themselves are small and the instruments do not introduce any radiation into the area other than the low levels emitted by standard weather radar, Stamnes said.

"The only aspect of the project I can think of that anyone might object to is a high-pitched sound emitted by one of the instruments measuring temperature," Stamnes said.

Atkasuk is being considered as the place to build the primary station because the remote community of about 200 residents offers electrical power and an airstrip. Barrow is being considered as a place to build one of the four border sites.

The program could mean long-term, steady employment for the estimated dozen or more people from rural communities hired to work at the stations, and periodic employment for others involved in the fields of construction, air logistical support, and maintenance, Stamnes said.

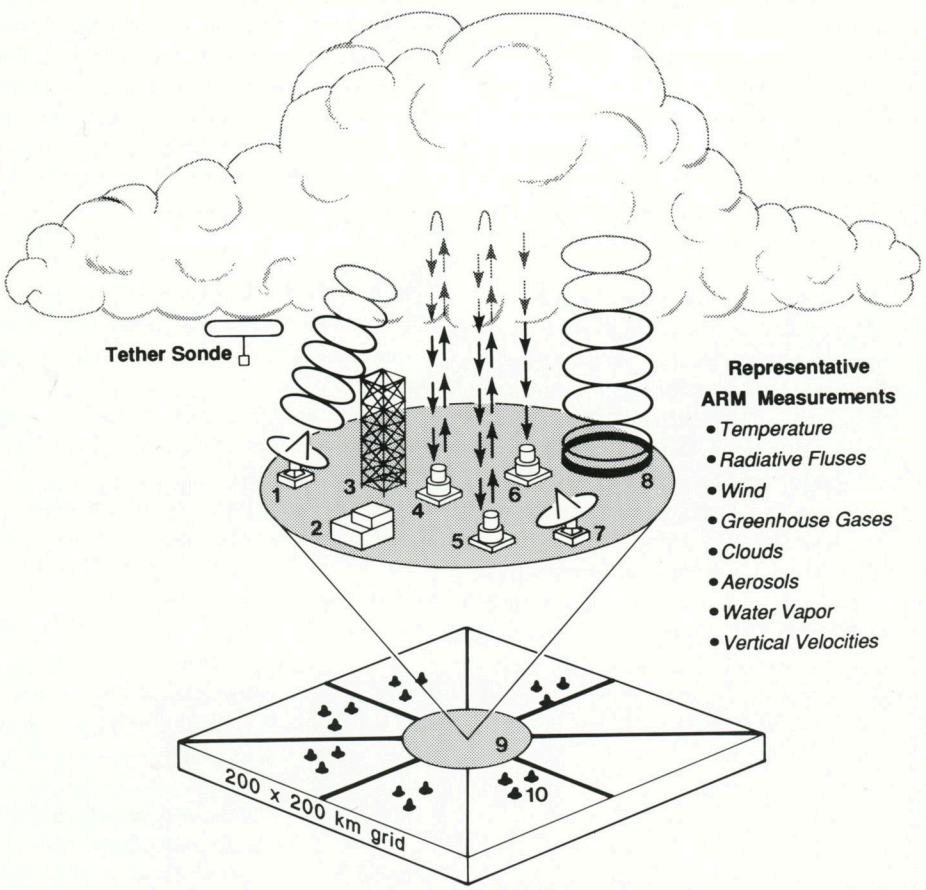
Stamnes and ARM Program Manager Bernie Zak interviewed Barrow residents for the first time last winter to get their suggestions on where to build the stations that house the measuring instruments, and to find out if residents supported the project. Rural community residents on the North Slope reacted positively and say they are interested in the results of the study.

"The people in these communities already have a keen sense that something is happening as far as changes in climate go," Stamnes said.

Federal researchers say there has been a 2.5 to 4°C warming in temperature in the Arctic accompanied by a slight increase in sea level over the past several years, possible indications of global warming.

A panel within DOE scanned the whole earth to find out where the most interesting things were happening concerning global climate changes. One of the five federal ARM sites began operating in April. That 150,000-square-mile area along the

continued on 12



ARM SITE—*The diagram above shows the array of instruments designed to measure all aspects of climate proposed for inclusion in a station to be built on the North Slope as part of the Atmospheric Radiation Measurement Program. The optical and sonic devices would probe the troposphere, the region up to eight miles above the earth in which clouds, rain, snow, and wind occur. Diagram key:* ***1****-doppler radar,* ***2****-calibration and support facility,* ***3****-radiation measurement tower,* ***4****-raman lidar,* ***5****-dial system,* ***6****-high resolution spectrometer,* ***7****-satellite data system,* ***8****-RASS profiling system,* ***9****-region covered by three-dimensional mapping network, and* ***10****-ARM extended field sites (diagram from the ARM Program Plan, February 1990, U.S. Department of Energy with modifications by Deborah Coccia).*

GI NOTES

CONGRATULATIONS!

Professor of Volcanology **John Eichelberger** was elected to Fellowship in the Geological Society of America in May and **Keith Echelmeyer** and **Keith Watts** were awarded tenure and promotion to the rank of associate professor in July.

Professor of Physics **Lou-Chuang Lee** received one of the American Geophysical Union's 1991 Editors' Citations for Excellence in Refereeing from James Van Allen, JGR-Space Physics. The editor's citation recognizes the time and diligence contributed by the reviewers who enhance the quality of AGU's journals.

Gwang-Son Choe, a space physics graduate student working under Professor Lee, received the 1991 Donald E. Billings Award in Astro-Geophysics for his paper, "Formation of Solar Prominences by Photospheric Shearing Motions." The international award is given for the best research paper written by a graduate student in solar physics and solar-terrestrial physics. It is granted by the Department of Astrophysical Planetary and Atmospheric Sciences, University of Colorado Boulder.

Yu Lin, a space physics graduate student working under Professor Lee, received one of the C.T. Elvey Memorial awards for the 1991-92 academic years. The Elvey award was established at the University of Alaska Fairbanks College of Natural Sciences to honor institute director Chris Elvey (1952-63). The award is given annually to recognize outstanding academic performance and research work by graduate students.

Geophysical Institute Assistant Professor **Paul Layer's** research on ancient rocks in southern Africa was written up in a July issue of Science magazine. Research by Layer and co-investigator Professor Alfred Kröner with the University of Mainz in Germany showed for the first time that geologic processes occurring today also were operating about 3 billion years ago.

Geophysical Institute Professor Emeritus **Robert Hunsucker** and his colleague Ray Greenwald from the Applied Physics Laboratory of Johns Hopkins University successfully organized an international symposium celebrating a decade of advances in radiowave probing of the high-latitude ionosphere and atmosphere. The three-day symposium, which started on August 10, took place 10 years to the day after Hunsucker and Greenwald organized the first international symposium on radiowave probing. The symposium was sponsored by the International Union of Radio Science Commission G, the National Science Foundation, the Geophysical Institute, and the Applied Physics Laboratory of Johns Hopkins University.

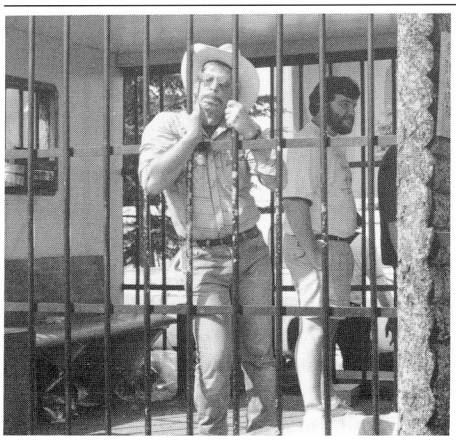
Governor and Mrs. Walter J. Hickel sent an official letter of congratulations to ASF Technical Secretary **Donna Sandberg** and her husband **Ray Sandberg** for being the first-place winners of the 1992 Urban Beautification Commission's Helen Walker Award. The couple received the award for decorating downtown Fairbanks by planting a colorful garden around their home. A professional artist, Ray Sandberg's palette splashed over into his yard which supported over 35 varieties of flowers.



Senior Applications Engineer **John Miller** received a Certificate of Appreciation from the National Aeronautics and Space Administration for significant contributions to NASA's mission in polar studies through the preparation and operational readiness of the Alaska Synthetic Aperture Radar Facility. Miller, project manager for ASF, received the award at a ceremony in Washington, D.C. in March. Certificates of Appreciation from NASA for outstanding work also were given to ASF employees **Kristina Ahlnaes, Paul Bundschuh, Brett Delana, Ronald Faust, Thomas George, Oliver Dean Gramling, Joanne Groves, Richard Guritz, Zuh-Yao Lee, Shusun Li, Craig Lingle, Coert Olmsted, Gregory Pippin, Thomas Reimers, Al Renfroe, Greta Reynolds, Walter Rutherford, Donna Sandberg, Lewis Shapiro, Mary Stuart, Larry Sweet, Hal Tippens, Rosemary Watabe, Wilford Weeks, Gunter Weller, Cindy Wilson,** and **Tracy Zeiler.** ASF employees not mentioned above were hired after NASA awarded the certificates.

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GEOCARE UPDATE—The Geophysical Institute Employee Assistance Fund Committee (GeoCare) established an endowment of $10,000 in May. The endowment will be held in perpetuity with only the interest earned and future fund-raising monies as spendable income. GeoCare continues to grow bimonthly through payroll deductions. The fiscal year-end balance for the endowment was $10,219.03 and the spendable income account balance was $1717.60.





GEOCARE GOLDEN DAYS—*Geophysical Institute Operations Manager Bob Grove bemoans his capture in the Golden Days jail (far left) while Alaska SAR Facility Mission Planner Greta Reynolds unveils a hidden talent for spinning the hula-hoop during GI festivities. The 1992 GeoCare Golden Days celebration and all-day food fest netted $1648.84, the largest profit to date for this annual event (photos by Evelyn Trabant).*

GI GRADUATES IN 1992—M.S. degrees were awarded at the 1992 UAF commencement exercise to **Victoria Avery**, geology; **Eric Breitenberger**, atmospheric sciences; **Gwang-Son Choe**, space physics; **James Dixon**, geophysics; **Tong Fei**, geophysics; **Richard Glenn**, geology; **Paul Gruzlovic**, geology; **Thomas Homza**, geology; **Andrea Krumhardt**, geology; **Jeffrey Rogers**, geology; and **Scott Stihler**, geophysics. Ph.D. degrees were awarded to **William Bristow**, space physics; **Fei Cao**, space physics; **Catherine Hanks**, geology; **Richard Honrath**, atmospheric chemistry; **Mingchi Lu**, applied geosciences; **Zhangai Luo**, atmospheric sciences; **Ling-Hsiao Lyu**, space physics; and **Chang-Quan Wei**, space physics.

NEW BOOKS PUBLISHED—*The Aurora Watcher's Handbook* by T.Neil Davis answers questions about the aurora, beginning with such basics as what causes the aurora, where and when it is most often seen, and how it can best be captured on film. The 230-page book includes numerous illustrations, ranging from cartoons to color plates and scientific drawings. The books can be purchased from the GI Business Office, or from the University of Alaska Press, First Floor Gruening, UAF, Fairbanks, AK 99775-1580. Hardbound copies cost $37.50 and paperbacks cost $22.50 (postage and handling included).

The four-volume *Encyclopedia of Earth System Science* was published recently by Academic Press. The encyclopedia covers 230 articles on a wide variety of earth science topics. The University of Alaska Fairbanks is represented with five entries, all from Geophysical Institute faculty. The entries were prepared by Professor Emeritus **Gerald Romick**, aeronomy; Professor of Geophysics **Gunter Weller**, arctic research; Professor Emeritus **Robert Hunsucker**, atmospheric gravity waves and traveling ionospheric disturbances; GI Director **Syun Akasofu**, polar aurora; and Professor of Geophysics **Willy Weeks**, sea ice.



DOUG SIGLER

WATER DAMAGE—*A sprinkler pipe burst in the Globe Room on the second floor of the Geophysical Institute in April, causing an estimated $50,000 worth of damage. Crews spent several days mopping up the water.*

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WELCOME to **Antonius Otto**, who joined the Geophysical Institute as a research associate of space physics in April. He received a B.S. in 1983 and a Ph.D. in 1987 from Ruhr-Universitat Bochum, Germany, where he was a research associate from 1987 through 1992. Otto is a member of the American Geophysical Union, the European Geophysical Society, and the German Physical Society.

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THANKS to the student interns who participated in the 1992 summer program at the Geophysical Institute. Working under faculty supervision, the undergraduate students got hands-on research experience in a graduate student setting. Participating in the program were **Christopher Brown, John Brown, Guy Delamarter, Naomi Fischer, Alok Gupta, Michael Helgerud, John Hughes, Amy Lautenschlager, Eric McGregor, Judy Mirick, David Muzzal, Craig Payne, Jennifer Simmons, Christopher Surridge, Kirk Walker, May Wineland, Brad Wolaver, and Eric Zizelman**.

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IN MEMORIAM—Larry Gedney passed away on May 18. Larry was an associate professor of geophysics at the Geophysical Institute from July 1966 until he retired in January 1987. His primary research interest was in resolution of tectonic deformation patterns in Alaska by seismological investigation. He wrote the Community Science Forum column for the Fairbanks Daily News-Miner and other Alaska newspapers for many years.

Mario Grassi died on May 3. Mario worked as a photographer and film developer for the Geophysical Institute from August 1967 until he retired in July 1983. His primary assignment at work was developing all-sky camera film in the GI Photo-Graphics Laboratory for space physics research. ✉

Cloud Research

continued from 9

Kansas/Oklahoma state line will measure cloud formation and solar radiation in the southern Great Plains.

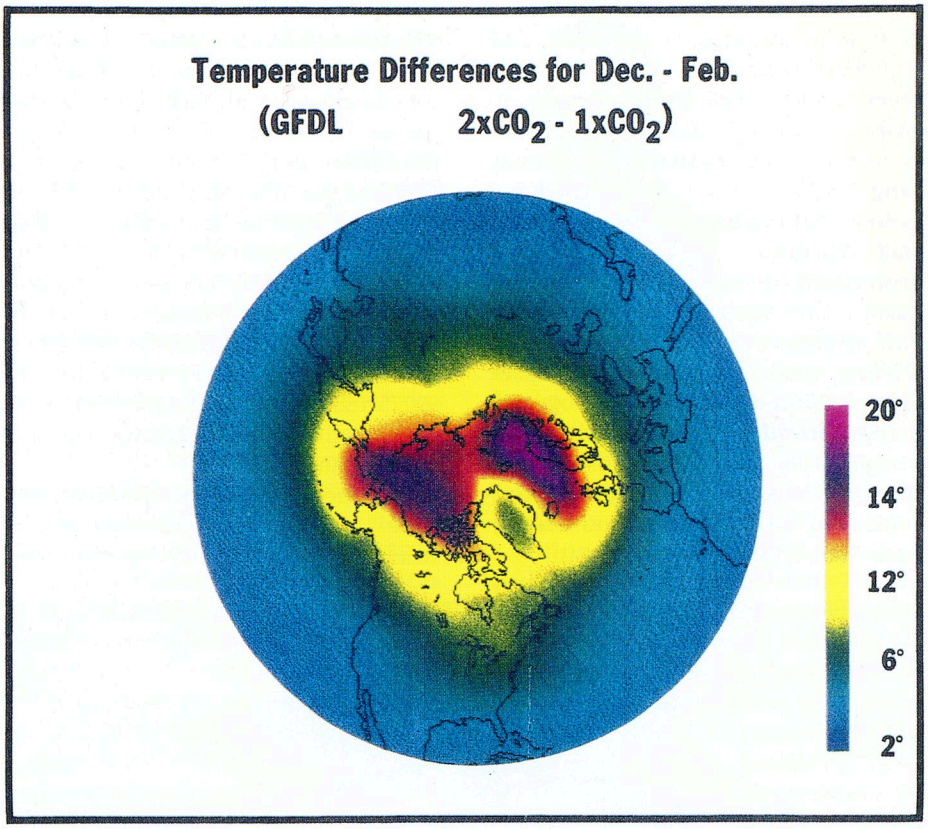
The North Slope was chosen as one of the ARM research areas because the Arctic is a land of extremes. The large seasonal variation in solar radiation and in the hydrologic cycle in the Arctic make the North Slope an excellent place to study cloud formation. Clouds at different altitudes greatly affect the earth's radiation balance both by preventing solar energy from reaching the earth, and by trapping terrestrial energy close to earth that otherwise would have escaped to space, Stamnes said.

Despite their effects on the earth's heat balance, clouds have not been analyzed enough in most global climate change models worldwide, Stamnes said.

"We don't know enough about how clouds form, their relation to and their effects on the atmosphere, or the feedback mechanisms involved," Stamnes said. "Evidence from about 20 climate models located around the world shows that on clear days the doubling of carbon dioxide in the atmosphere indicates a trend toward warming, but, if you add clouds to the models, you get a whole range of different results."

In its natural state, the atmosphere acts like a blanket that keeps enough heat on the earth to sustain life.

"The concern is that the atmosphere is building up so many greenhouse gases through the burning of fossil fuels coupled with deforestation that the atmosphere will capture too much of the sun's rays and become too warm," Stamnes said. "The ultimate concern is that the earth will heat up much faster than it has in the past. If that happens, it could have a great impact. Remember, we have the only planet in the solar system with life on it."



GLOBAL CLIMATE CHANGE—*The figure above highlights the sensitivity of the arctic region to changes in global concentrations of carbon dioxide, a "greenhouse gas" many scientists believe could facilitate the unnaturally fast warming of the earth (courtesy of ARM, U.S. Department of Energy, 1990).*

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