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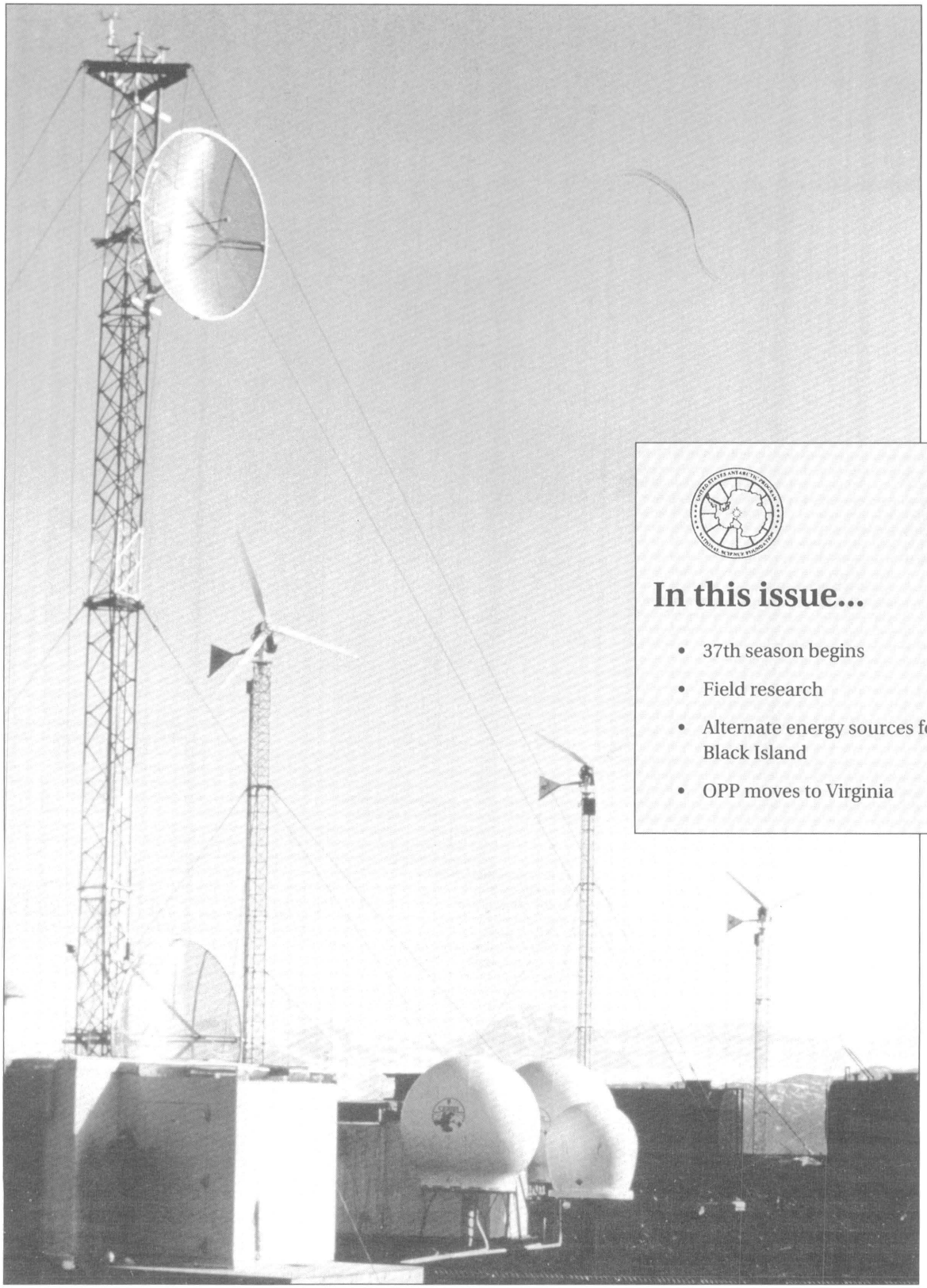

In this issue...

- 37th season begins
- Field research
- Alternate energy sources for Black Island
- OPP moves to Virginia

Editor, Winifred Reuning

Antarctic Journal of the United States, established in 1966, reports on U.S. activities in Antarctica, related activities elsewhere, and trends in the U.S. Antarctic Program. The Office of Polar Programs (National Science Foundation, Washington, DC 20550) publishes the journal five times a year (March, June, September, December, and an annual review issue).

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The Director of the National Science Foundation has determined that the publication of this periodical is necessary in the transaction of the public business required by law of this agency.

Submitting manuscripts to the *Antarctic Journal* quarterly issues

The editor of the *Antarctic Journal* will consider unsolicited manuscripts for publication in the *Antarctic Journal.* Format and content requirements for articles are summarized below. Interested authors should review previous issues for style and content or contact the editor directly.

Style

The audience for the quarterly issues is broad in background and interests, so authors should make sure that their articles will be intelligible to readers outside of their scientific discipline or other area of expertise. Avoid specialized jargon and abbreviations, but use technical terms as necessary. Define terms likely to be known only by readers who are familiar with subject. Spell out acronyms where they first appear, including standard scientific terms and chemical abbreviations, as well as names of organizations.

Papers will be edited to improve style, clarity, and grammar. Authors will have the opportunity to review their edited manuscripts before publication, but galley proofs are not furnished.

Articles: Feature articles should be no longer than 1,500 words, but there is no limit on the number of illustrations (figures, tables, or photographs). Appropriate topics include recent or significant science discoveries or advancements, cold-regions engineering, special support activities or issues, history, environmental topics, and policy issues.

Notes: Shorter articles, 500 to 800 words, will also be considered. Illustrations may be submitted with these articles, but notes should not include more than three figures. Appropriate topics for notes include meeting reports or announcements, new or improved technology, polar publications, and support or related activities.

Manuscript format

Manuscripts may be submitted in the following formats. Because the final publication is prepared on a computer-based system, please make sure that symbols, characters, accents, and other similar items are clearly marked on a typed copy of the paper. The following formats will be accepted:

- Typed manuscripts: Submit two double-spaced copies.
- Computer disk: Manuscripts may be prepared on an IBM or compatible computer and submitted in ASCII, WordPerfect, or Word for Windows format. Include one paper copy.
- Electronic mail: Manuscripts may be submitted via OMNET (mailbox DPP.PCI; include "Antarctic Journal" in the subject line) or Internet to WREUNING@NSF.GOV. Please mail one double-spaced, typed copy of your submission if the manuscript is submitted electronically.

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Cover: Windmills at the Black Island satellite communications facility are providing an alternative source of energy. This site, along with new facilities under development at the South Pole, are among the first uses of alternative energy by the U.S. Antarctic Program to support research on the southernmost continent. (NSF photo by Lynn Simarski.)

From the Director—USAP 1993–1994: Looking forward

For the scientists who participate in the U.S. Antarctic Program (USAP), the beginning of each field season is a time of anticipation—the culmination of months, or even years, of research and planning. They have the opportunity to "discover" Antarctica—whether it is their first season or their tenth—to see its beauty and to probe the complex relationships that occur in this unique natural laboratory.

As one of these scientists, I learned first-hand that Antarctica offers special opportunities. For more than a decade I have had the privilege of working in Antarctica as a participant in USAP. Focusing on the ecology of polar oceans and in the ice-edge zone, I have worked on the sea ice near McMurdo Station, from aboard research ships along the western coast of the Antarctic Peninsula and from icebreakers in the Weddell Sea region. Through these experiences, I have come to appreciate the unlimited possibilities of antarctic research, as well as the challenges that USAP managers confront to support this prestigious research program.

During the last two decades, the U.S. antarctic research program has grown and matured. Today's research program looks beyond cataloging and describing the physical characteristics of the continent and the surrounding oceans. After 37 years of data collection and analysis, U.S. scientists are applying what they have learned to global problems and are combining knowledge of antarctic history, processes, and systems with advanced technology to extend our understanding of global processes and change.

Among this year's more than 120 projects are several that unite researchers from various disciplines and institutions. Scientific understanding benefits from such projects as these because they encourage dialogs, break down paradigms, and give researchers a new way of seeing problems. For example, along the Antarctic Peninsula, biologists, oceanographers, ecologists, and others are continuing their long-term ecological investigation of how changes in climate and environmental processes influence the stability of a marine ecosystem. The cooperative efforts of this group provide new insights into the complex relationships between ecosystems and the marine environment, insights that can be applied outside the polar regions. Their success encouraged a second group to begin a long-term investigation of simple terrestrial ecosystems—a project that begins this year in the McMurdo Dry Valleys.

Other projects demonstrate that the unique physical characteristics and geographic location of Antarctica can provide scientists with observational conditions that improve their ability to study this planet or extend their investigations beyond Earth into space. The recent results from work conducted at the South Pole Station's Center for Astronomical Research in Antarctica (CARA) exemplify this aspect of antarctic research. In June 1993, two CARA researchers announced that through their antarctic work they had evidence of cosmic structures that formed about 1 million years after the Universe began, confirming previous observations made by instruments on unmanned satellites. Until recently, the available data suggested that primal

Continued on page 6

NSF on the move

In September 1993, offices and directorates of the National Science Foundation began moving from offices in Washington, DC, to a new building in Arlington, Virginia. To ensure that normal Foundation operations are affected as little as possible, files, equipment, and other office materials are being moved in increments during the weekends. The Office of Polar Programs is scheduled to move on 10 December 1993.

New telephone and fax numbers are being introduced over the course of the fall and concurrent with the relocation of each directorate. The NSF telephone directory is being updated weekly during the transition and is posted on the Foundation's Science and Technology Information System (STIS). Additionally, for several months following the move, calls placed to the old numbers will be intercepted, new numbers will be provided, and the call will be forwarded to the new location in Arlington.

The new mailing address, however, will become effective on a one-time basis for all of the Foundation, concurrent with the relocation of the central mail room. Mail service is assured to all Directorates throughout the move process, regardless of their location, through a carefully developed transition plan.

As of 25 October 1993, the new mailing address will be

National Science Foundation
4201 Wilson Boulevard
Arlington, VA 22230

NSF encourages you to use e-mail to communicate with Foundation personnel over the course of the move, because e-mail addresses will be unaffected by the relocation. Forms and publications also will continue to be available via this method (BITNET:pubs@nsf or Internet:pubs@nsf.gov). When placing your request, please be certain to include the NSF publication number and title, your name, and your complete mailing address.

The Foundation anticipates minimal disruption to program activities over the course of the relocation process and is committed to continued responsive service during this transition period.

New long-term ecological research project featured during 37th research season for U.S. Antarctic Program

Viewed from above, the valleys form a mosaic of ice-covered lakes, meltwater streams, patterned ground, and glaciers, spreading from the coast to the edge of the polar plateau. Viewed closer, the floors of valleys, strewn with glacial till and punctuated with rocky outcrops, seem more like the landscape of a barren, uninhabited world.

This is the environment of the ice-free valleys of southern Victoria Land, known as the McMurdo Dry Valleys, the largest ice-free region in Antarctica. Less than 10 centimeters of percipitation falls each year, and the low surface albedo and intense winds flowing from the polar plateau accentuate the desert conditions, making this one of Earth's most extreme deserts. Ice-free for nearly 4 million years, the McMurdo Dry Valleys were formed by advances and retreats of Antarctica's glaciers.

Superficially, the valleys appear sterile and not a likely site for ecological studies, but investigations since the late 1950s have demonstrated that unique terrestrial desert ecosystems exist at a microbial level. They are simple systems with no vascular plants or vertebrates and only a few insects. The number and type of species are both low, but the interactions among species and between the biological and physiochemical components in the lakes, streams, and soil are complex.

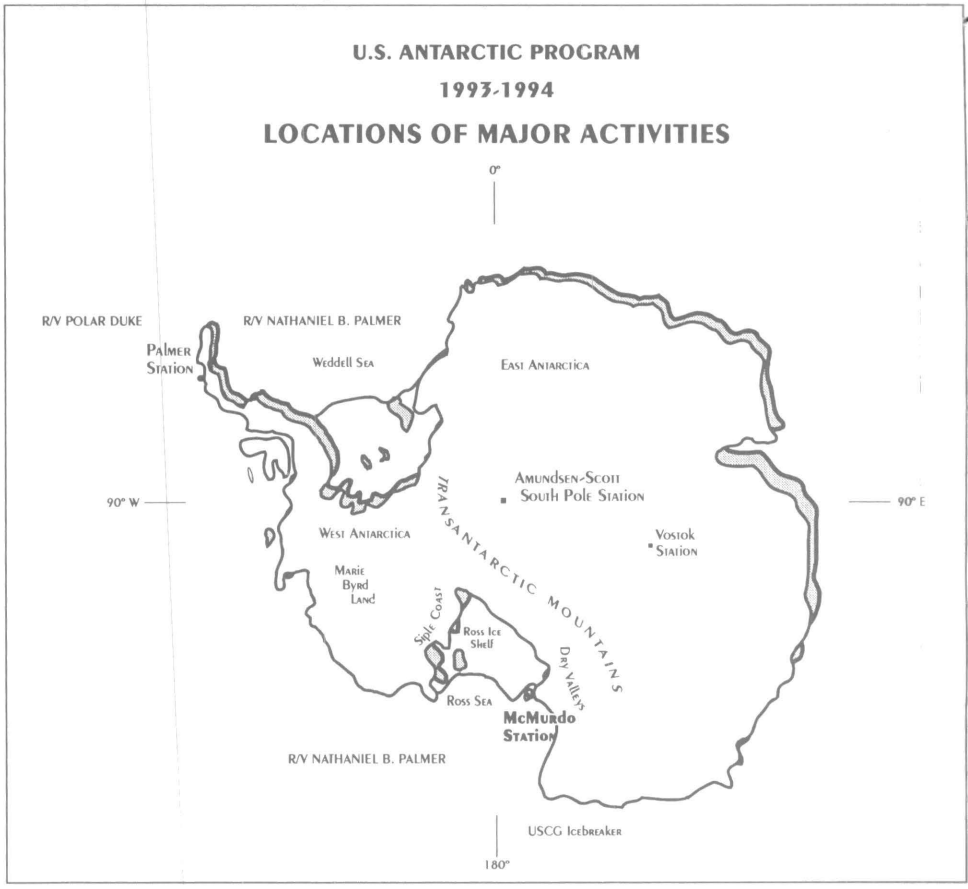
Because the simplicity of the ecosystem makes this an ideal place to study fundamental ecological principles, this region has attracted scientists from various disciplines for many years. From data obtained here, scientists hope to develop a model which will explain how environmental changes affect ecosystem interactions; that model may also be useful for learning how more complex temperate ecosystems respond under stress.

During the 1993–1994 austral summer, biologists will begin a new long-term study of ecology in the McMurdo Dry Valleys. The study complements another long-term ecology project at Palmer Station on the other side of the continent. It is one of more than 120 projects in biology, oceanography, climatology, geology, geophysics, glaciology, astronomy, and aeronomy to be supported as part of the U.S. Antarctic Program (USAP), which is funded and managed by the National Science Foundation (NSF).

"Antarctica contributes to our understanding of global processes and change," explains Office of Polar Programs Director Cornelius Sullivan, a leading polar scientist overseeing his first season as head of the USAP. "The continent's physical processes influence the oceans and climate around the globe, and the health of Antarctica's ecology is of key concern to the rest of the planet. Antarctica also provides an unmatched window onto the universe of astronomy and astrophysics."

Among the research highlights of the 1993–1994 austral summer season will be investigations into the stability of Antarctica's ice sheets; life under the ozone hole; use of the ice at the South Pole as a neutrino detector; cosmic rays in the antarctic atmosphere; and the development of the cold antarctic water that fans out across the bottom of the world's oceans.

Studies will be carried out at three year-round research sites—McMurdo Station at the edge of the Ross Sea, Amundsen–Scott South Pole Station, and Palmer Station near the Antarctic Peninsula. Research will also be launched from field camps located at McMurdo Dome on the polar plateau side of the Dry Valleys, and at Upstream B (about 800 miles southwest of McMurdo), as well as on the program's two research ships, the *Polar Duke* and the *Nathaniel B. Palmer*. For the first time, the icebreaking research ship *Nathaniel B. Palmer*, which begins its second antarctic season this year, will sail on seven oceanographic cruises in the Ross, Amundsen, Bellingshausen, and Weddell Seas, mainly in ice-bound regions not accessible by other research vessels. Support for the field program is provided by an NSF contractor Antarctic Service Associates and personnel from the U.S. Navy, Army, Air Force, and Coast Guard.



Collaboration with other Antarctic Treaty parties during the 37th consecutive year of U.S. research in Antarctica includes airlifts from McMurdo Station to Russia's Vostok Station to ensure continuation of the cooperative Russian–French–U.S. deep ice-coring project. This important drillhole has passed 2,700 meters in depth, providing researchers with ice core that is 300,000 years—older than that cored by the Greenland Ice Sheet Project completed during the 1993 northern summer.

Highlights of this season's antarctic research

Life under the ozone hole. Oceanographers aboard the *Nathaniel B. Palmer* will investigate how the increased flux of ultraviolet (UV) radiation, resulting from the antarctic ozone "hole," may harm ocean life, especially at the ice edge, the zone so critical for seabirds and other polar life. Research has already shown that increased exposure to wavelengths of UV radiation between 280 and 320 nanometers (known as UV-B) inhibits photosynthesis by phytoplankton at the base of the oceanic food chain. During the *Nathaniel B. Palmer*'s cruise in the Weddell and Scotia Seas, scientists will quantify how ozone depletion affects the most basic levels of marine life and how vertical mixing by oceanic currents may mitigate UV damage.

Exploring a sub-ice basin. For more than a decade, the discovery of enigmatic marine fossils in rocks collected high in the Transantarctic Mountains has fueled debate about the history and stability of Antarctica's ice sheets. Deep beneath East Antarctica's ice lies a depression in the land surface—the Wilkes subglacial basin, a possible source of the marine diatom fossils and sediments now stranded at high elevations. This year, a 400-kilometer-long seismic survey will allow geophysicists to "see" the basin beneath the ice, providing clues to whether marine waters encroached far inland during an ice-free period and to determine whether ice scoured out the sea sediments, carrying them to what are now about 2,500 meters above sea level.

Ross Sea cruise. Geophysicists aboard *Nathaniel B. Palmer* will study undersea sediments to plot the growth and decay of the ice sheet in the Ross Sea region since the last glacial maximum 15,000 years ago. They are trying to delineate how far the west antarctic ice sheet expanded and to pinpoint what set off the ice retreat in the Ross Sea.

Drilling McMurdo Dome. Antarctica's ice is an archive of climate history, and a new project to drill 600 meters through the ice of McMurdo Dome in Victoria Land should furnish an annual record back 50,000 years or more—well into the last ice age. The climate history may also reveal how Antarctica's ice sheets responded as temperatures and sea level rose with the close of the ice age.

West Antarctica's fast-changing ice. West Antarctica's ice sheet, Earth's largest remaining marine-based ice sheet, may have collapsed, or melted rapidly, some 125,000 years ago. The ice sheet, today continues to change rapidly with its stability dependent on ice streams flowing swiftly from the continent's interior. Because this ice sheet is susceptible to change brought about by global climate change, U.S. glaciologists continue to focus on defining what physical mechanisms and environmental processes affect the ice sheet to determine whether the ice sheet is headed for another collapse.

Recent studies show that volcanoes under the ice set the streams aflow—suggesting that antarctic geology may contribute as much as climate does to the ice sheet's stability. Several research groups will return to the Siple Coast along the western edge of the Ross Ice Shelf this year to study the heavily crevassed boundaries between the ice streams and the stagnant ice around them.

Texas in Antarctica? Antarctica's ancient history is also under scrutiny, in particular the theory that North America and Antarctica were once neighbors, before rifting apart through continental drift about 700–800 million years ago. An expedition to the Shackleton Range, considered an enigma in antarctic geology and seldom visited by U.S. geologists, will study the area and compare it to rocks in the southwestern United States.

Icy observatory for neutrinos. Astronomers will use the ice sheet at the South Pole as a massive detector for high-energy, subatomic particles called neutrinos. A pioneering instrument called the antarctic muon and neutrino detector array (AMANDA) will be built using holes drilled more than a kilometer deep in the ice. Strings of photomultiplier tubes will be lowered and frozen into the holes—allowing the ice itself to be used to seek neutrinos that have passed through the Earth. AMANDA is one of the first-generation neutrino telescopes, contributing to an embryonic branch of astronomy.

Giant cosmic balloons. As part of a collaborative effort by more than 30 scientists from the United States, Japan, and Poland, two huge balloons will be launched near McMurdo to study cosmic rays. The balloons will allow instruments to be lofted above most of the Earth's atmosphere. As the balloons trace a rough circle over central Antarctica, detectors on board will look at the cosmic-ray energy spectrum in the ultra-high-energy range and also will probe high-energy nuclear reactions that naturally produce effects surpassing those created by an accelerator.

Uncharted bottom water. The waters on the continental shelves surrounding Antarctica eventually form the characteristic bottom water that spreads out beneath the seas across the globe, influencing oceanic circulation and world climate. During a research cruise of *Nathaniel B. Palmer* in the Bellingshausen and Amundsen Seas, U.S. investigators systematically study oceanic processes and phenomenon that may contribute to the formation of antarctic bottom water outside the Weddell Sea. The cruise will also enable them to investigate the unusual and little-known Amundsen–Bellingshausen Continental Shelf.

Unabated hurricane-force winds. Along the Adélie Coast of Antarctica, on the Indian Ocean side of the continent facing Australia, intense and unabating winds, frequently of hurricane force, have been noted since the beginning of the century. These winds, known as katabatic or gravity-driven winds, will be the focus of an ongoing project that brings together U.S., French, and Australian scientists.

Environmental Stewardship

The 1993–1994 austral summer marks the fifth and final year of the Safety, Environment, and Health Initiative, which provides additional funding for a variety of special projects to improve safety and environmental practices. Included in the environmental improvement effort was the general cleanup of two former U.S. research stations—East and Hallett Bases—which will have been completed by the season's end, with East Base converted to a historic site.

As part of the initiative, National Science Foundation managers and contractor and Navy personnel worked together closely not only to improve waste-management practices but also to make USAP operations more efficient and environmentally sound. Much of the old waste was removed from McMurdo Station. More environmentally sound fuel-handling practices were put into place. Burning and incineration in Antarctica have been halted, and a solid and hazardous waste-management program—with emphasis on recycling—is now in force. Solar and wind energy have been harnessed to power the new communications station on Black Island near McMurdo, and plans are underway for new laboratories at the South Pole that will be heated almost completely by solar energy.

This will be the first research season under the new waste-management regulations issued under the Antarctic Conservation Act. In keeping with the Protocol on Environmental Protection to the Antarctic Treaty, the regulations ban certain substances from the continent and restrict the import and use of particular pollutants. Virtually all waste now generated by research activities, including projects at the South Pole, will now be removed from Antarctica.

Tourism and environmental stewardship. Tourists began visiting Antarctica in the late 1950s when Chile and Argentina supported four cruises to the South Shetland Islands. Although the first U.S. company began operating in Antarctica in 1966, tours similar to those conducted today started in 1969 when the *Lindblad Explorer* was built specifically to support antarctic tourism.

Since that time, thousands of tourists have come to Antarctica by ship and airplane. Each year, the number has grown, with about 6,000 tourists supported by U.S. companies visiting during the 1992–1993 austral summer. The impact of these visits on the environment has not been evaluated.

Most tourist ships visit the Antarctic Peninsula in the region of Palmer Station. On nearby Torgersen Island, researchers are beginning a systematic study of the impact of antarctic tourism on the environment. Overall, these plans and accomplishments exemplify NSF's commitment to continued environmental stewardship as a fundamental element of the antarctic research program.

From the Director

Continued from page 3

radiation was perfectly smooth, but these new observations suggest that some masses in the early Universe were denser than others.

Most Americans do not have the opportunity to experience Antarctica. For them, Antarctica is a distant world, pristine in its natural beauty. Through the media, they may have learned of the growing problem of ozone depletion and its damaging effects, or they may be aware of the efforts of the Treaty Consultative Parties and others to protect the continent's environment. Those of us who work and live in Antarctica have obligations to those who cannot share the experience. We must strive to continue the well-established record of excellence in scientific research that U.S. program has gained since 1957. We must also work together to improve not only public understanding of antarctic research but also awareness of the importance of Antarctica to global processes.

This effort may take many forms. To reach beyond the polar science community, NSF will sponsor, this austral summer, a 4-week course titled "Biological Adaptations of Antarctic Organisms." Taught at the Crary Science and Engineering Center at McMurdo Station by experienced antarctic scientists, the course is designed to provide hands-on field experience to young scientists with diverse bckgrounds and encourage interest in polar research. Additionally, beginning in the 1994–1995 austral summer, NSF will support a program for talented high school students, similar to NSF's young scholar's program. It will offer a highly select group of high school students and teachers the opportunity to participate directly in field research.

This year's research program exemplifies the extent to which antarctic research has changed during the last 50 years. By using advanced technology, we are improving our observational capabilities and increasing the size of the U.S. antarctic research program without increasing the human impact on the environment. Unmanned systems such as USAP's automated weather stations and the ultraviolet-radiation monitors provide data that are available to scientists worldwide. Such projects as the antarctic long-term ecological research sites and the investigations of the west antarctic ice sheet combine field observations with data obtained from satellites and unmanned monitors. With these data, other scientists are able to develop models applicable not only to antarctic processes but also to those in other regions of the world. Through cooperative agreements with other Federal agencies such as the National Aeronautics and Space Administration, we are able to bring cutting-edge technology previously not available to antarctic researchers. Projects such as the NSF/NASA remotely operated submersible are enabling scientists in the United States to observe processes in Antarctica via satellite communication links. To improve USAP support operations, we are enlisting the efforts of U.S. small businesses that have experience in the polar regions managing or developing such technology as waste disposal and communications systems. We hope that by encouraging a partnership with industry we will be able not only to solve some of the problems that confront USAP but also to help expand the knowledge of U.S. industry for polar-related problems.

Finally, we have extended the program to disciplines outside traditional polar research and have expanded the educational component of our work. All of these initiatives—continued scientific excellence, advancing our technological capabilities, education, and environmental stewardship—should guide not only the program managers but each USAP participant.

Cornelius Sullivan
Director, Office of Polar Programs
National Science Foundation

Operations highlights in continental Antarctica, 1993–1994 austral summer

Date	Event
1993	
22 August	Winter-fly-in 1993 to McMurdo Station begins—eight flights between Christchurch, New Zealand, and McMurdo Station
5 October	First U.S. Air Force C-141 Starlifter flight to McMurdo Station
9 October	Helicopter-supported science begins near Ross Island
18 October	USAP ski-equipped Hercules (LC-130) airplanes arrive at McMurdo Station
25 October	Field operations begin at McMurdo Dome, southern Victoria Land
26 October	Amundsen–Scott South Pole Station opens for austral summer
28 October	Field operations at Upstream B, Siple Coast, begin
7 November	U.S. Air National Guard squadron 109 arrives at McMurdo Station to augment LC-130 support to USAP (first group)
8 November	Royal New Zealand Air Force wheeled C-130 flights to McMurdo Station begin
16 November	First flight to Russian station Vostok, East Antarctica
4 December	Last 109th Air National Guard flight to Christchurch, New Zealand (first group)
11 December	McMurdo Sound sea-ice runway closes—all wheeled airplane flights end and air operations transfer to Williams Field skiway on the Ross Ice Shelf
1994	
1 January	U.S. Coast Guard icebreaker *Polar Sea* arrives at the McMurdo Sound ice edge to begin icebreaking operations
4 January	U.S. Air National Guard squadron 109 arrives at McMurdo Station to augment LC-130 support to USAP (second group)
18 January	*Nathaniel B. Palmer* arrives at McMurdo Station; *Nathaniel B. Palmer* will conduct two science cruises, a marine geology and geophysics investigation, and an ocean science study while in the Ross Sea area
18–22 January	Tanker ship moored at McMurdo Station ice pier to offload fuel
25 January	Russian research and supply ship *Federov* arrives at McMurdo Station
27–31 January	The supply ship *Green Wave* moored at McMurdo Station ice pier to offload cargo (first delivery)
13 February	*Nathaniel B. Palmer* departs McMurdo Station enroute to the Antarctic Peninsula
14–19 February	The supply ship *Green Wave* returns to McMurdo and is moored at the ice pier to offload a second delivery of supplies
15 February	*Polar Sea* leaves McMurdo Station area
22 February	Amundsen–Scott South Pole Station begins winter operations
28 February	McMurdo Station begins winter operations

Research ship operations, Antarctic Peninsula region, 1993–1994

Date	Event
1993	
13 August	First *Polar Duke* cruise (PD93-7)—1993–1994 austral summer operations begin with this cruise that includes support to the long-term ecological research (LTER) program
3 October	PD93-8—support for marine biology projects focus on the effects of enhanced exposure to UV-B along the Antarctic Peninsula
10 October	First *Nathaniel B. Palmer* cruise (NBP93-6)—support studies into the photosynthetic response of phytoplankton to ultraviolet radiation in the Weddell and Scotia Seas
12 November	NBP93-7—21-day port stay in Punta Arenas so that hazardous materials can be transferred from *Polar Duke* to *Nathaniel B. Palmer* for transport to McMurdo Station and shipment to the United States
24 November	PD93-9—support studies of the ice-edge bloom and zooplankton in the Weddell Sea
4 December	NBP93-8—begin transit to the Ross Sea and McMurdo Station via Palmer Station to collect hazardous material for transport to McMurdo Station; marine geology and geophysics projects supported while enroute to McMurdo and in the Ross Sea area
1994	
1 January	PD94-1—LTER cruise from King George Island to Marguerite Bay to the western Antarctic Peninsula
20 January	NBP94-1—support marine geology and geophysics, including a high-resolution, single-channel seismic survey, in the Ross area
13 February	NBP94-2—depart McMurdo area for return to the Antarctic Peninsula; return cruise includes the first oceanographic survey of the Amundsen–Bellingshausen continental shelf region; cruise concludes in Punta Arenas, Chile, and is followed by a 45-day shipyard period
25 February	PD94-2 through PD94-4—move cargo, supplies, and personnel between Palmer Station and South America; followed by a 30-day maintenance period in Punta Arenas, Chile
29 May	NBP94-3—15-day sea trials to test equipment adjustments
9 June	PD94-5—support along the Antarctic Peninsula marine biology investigation of winter behavior of krill
18 June	NBP94-4—support for ANZFLUX (winter flux experiment in the eastern Weddell Sea), a multidisciplinary investigation of the dynamics and thermodynamics of momentum, heat, and salt flux through the upper ocean and ice cover into the atmosphere
14 July	PD94-6—support three marine geology projects in the Chilean fjords region
1 September	NBP94-5—support a comprehensive study of physical and chemical properties of sea ice in the Bellingshausen, Amundsen, and Ross Seas

Field research, 1993–1994

Biology and medicine

Understanding how antarctic flora and fauna interact has gained new significance in the last decade. Without this understanding, scientists cannot evaluate how life on the continent and in the surrounding oceans responds to environmental changes nor can they discern or predict how the presence of people in Antarctica may affect the continent's ecosystems. Their investigations, however, are not limited to the potential affects of a human presence in Antarctica. For more than a decade, the antarctic ecosystem has been exposed to enhanced levels of biologically harmful UV-B radiation (solar ultraviolet radiation with wavelengths between 280 and 320 nanometers). Although the full impact of long-term exposure remains unknown, biologists believe that this exposure has altered primary productivity and suspect that it is affecting species composition within communities, shifting and subsequently altering ecosystem dynamics. To understand how marine organisms respond to and protect themselves from increased exposure to ultraviolet radiation, biologists collect samples of and document changes to antarctic ecosystems during the austral spring at the height of ozone depletion.

Photochemistry of antarctic waters in response to changing ultraviolet radiation fluxes. *Kenneth Mopper, Washington State University.* Decreases in stratospheric ozone over Antarctica result in an increase in the ultraviolet radiation reaching the euphotic zone—upper layers of the ocean where organisms dependent on light are found. This increase may lead to cellular damage in the organisms resulting in photoinhibition and decreased productivity. Cellular damage can occur either intracellularly or at the cell surface from bimolecular reactions with externally generated, reactive transient species. Extracellular damage will depend to a large degree on the photochemistry of the seawater surrounding the cell. Little is known, however, about the photochemistry of the unique antarctic waters. The objective of this project, which integrates field and laboratory work, is to obtain baseline information in the euphotic zone regarding marine photochemistry related to changes in ultraviolet radiation levels. We will take *in situ* measurements of photochemical production rates and steady-state concentrations of a suite of reactive species, of dissolved organic matter degradation products, and of downwelling ultraviolet radiation. Additionally, we will determine the flux by *in situ* chemical actinometry, action spectra for photochemical production of various reactive species and for the products of dissolved organic matter degradation, and we will determine the properties of fluorescence and absorbance in dissolved organic matter. This information will serve as a basis for understanding and predicting the effects of ultraviolet, radiation-induced, marine photochemical processes on the productivity and ecology in the euphotic zone. (S-002)

Physiological development and survival of juvenile Weddell seals. *J. Ward Testa and Michael A. Castellini, University of Alaska, Institute of Marine Sciences.* For Weddell seals, the first year of life is critical. Although this period is likely to have a significant effect on both their survival to adulthood and their eventual reproductive success, it is the least known aspect of the life cycle of any mammal. During this time, the seals experience a 6-week period of maternal dependence, develop swimming and diving abilities, and disperse from natal colonies as shore-fast ice turns to pack ice and open water. Our objective is to elucidate some aspects of the physiology, behavior, and survival of Weddell seals during their first year. Using satellite telemetry, we will record physical and physiological changes related to the amount of maternal care and weaning and to the development of diving abilities. We will also track the development of diving behavior and dispersal of pups. These data will be used to compare diving and movements by 1- to 2-year-old juveniles. In a related project, we will examine the maternal, physical, physiological, and behavioral factors that affect the movements of pups during their first year and possibly condition them for survival. As part of a long-term study of population dynamics, we will continue to measure the population size, survival rates, and productivity of Weddell seals in McMurdo Sound. These data provide a context for interpreting yearly variations in the condition or behavior of juveniles. (S-004)

The role of antifreeze proteins in freezing avoidance by antarctic fishes. *Arthur L. DeVries, University of Illinois.* Antarctic fish live in waters that are constantly at the freezing point of body fluids. These fish have adapted to these conditions by developing natural antifreeze molecules. The evolutionary aspects of these "antifreezes" are of considerable scientific interest. During the 1993–1994 austral summer, we will examine the physiological and mechanistic processes involved in freezing tolerance to understand more clearly how antifreezes evolved. We will focus on the synthesis of antifreezes and the factors that control their synthesis, secretion, fluid and tissue transport, and conservation. Besides helping scientists gain a better understanding of how creatures adapt to extreme environments, this project will also provide data that may have implications for human pathologies, nucleation theory, and crystallography. (S-005)

Effects of ultraviolet radiation on the photosynthesis of phytoplankton in the antarctic marginal ice zone. *Patrick J. Neale and John J. Cullen, Bigelow Laboratory for Ocean Sciences.* In previous investigations, researchers have shown that increases in middle ultraviolet radiation associated with the antarctic ozone hole inhibit the photosynthesis of phytoplankton. Using these results, researchers have estimated the effect of ozone depletion on primary productivity in the marginal ice zone. Our objective is to refine this assessment by specifying detailed, wavelength-dependent biological weighting functions for the inhibition of photosynthesis by ultraviolet radiation. We will also consider the mitigating effects of vertical mixing. In the marginal ice zone, we will measure biological weighting functions of phytoplankton under controlled conditions and then apply these in a new model of photosynthesis to predict primary productivity *in situ*, as well as under altered ultraviolet irradiance. These predictions will be compared with observations of samples from the water column and with measurements during incubations of several hours under

different irradiance regimes. Using the results of these comparisons, we will test the model and quantify the potential artifact of long incubations. Assumptions about the kinetics of photoinhibition and recovery that are critical to modeling the effects of vertical mixing will be examined using time-course experiments. The results will be incorporated into a model of photosynthesis and photoinhibition in the water column for predicting the influence of ozone depletion on marine primary production, particularly in the marginal zone. (S-007)

The biology of gelatinous zooplankton: Investigations on the trophic relationships *Salpa thomponsi* and *Salpa gerlachei* in the southern oceans. *G. Richard Harbison, Woods Hole Oceanographic Institution.* Two species of salps, *Salpa thompsoni* and *Salpa gerlachei*, live in the southern oceans near the Antarctic Peninsula. Both form immense blooms that nearly dominate the biomass. A knowledge of the biology of these species is essential to understanding the trophic relationships and global processes occurring in the southern oceans. To develop an energy budget for them, we will investigate the feeding rates, defecation rates, assimilation efficiency, growth, reproduction, and metabolism of both species. We will measure feeding rates in both the laboratory and in the field and will compare the results. Growth, reproduction, and metabolism will be measured only in the laboratory. The potential effect of hyperiid amphipod parasites on the growth and reproduction of salps will also be considered. In the laboratory, we will observe several species of fish that inhabit the ocean near Palmer Station to study their feeding on salps and other gelatinous zooplankton. Through these studies we will assess the usefulness of gut-content analysis to identify and quantify the remains of gelatinous organisms. These studies will provide important data on the trophic position of salps in the southern oceans, both as consumers of phytoplankton and as prey of other organisms. These studies are an essential prelude to further studies on recruitment and population structure in southern-oceans planktonic communities. Additionally, the results of our investigation will provide basic information on the ways in which oceanic zooplankton cope with the seasonally variable food resources of the southern oceans. (S-011)

Long-term ecological research (LTER) on the antarctic marine ecosystem: An ice-dominated environment. *Robin Ross, Langdon Quetin, Barbara Prezelin, and Raymond Smith, University of California at Santa Barbara; and William Frazer, Wayne Trivelpiece, and Eileen Hofmann, Old Dominion University.* The annual advance and retreat of sea ice may be the major physical determinant of spatial and temporal changes in the structure and function of antarctic marine communities. Interannual cycles or trends in the annual extent of the pack ice may also have significant effects at all levels of the food web—from total annual primary production to breeding success among seabirds. Historical records indicate a 6- to 8-year cycle in the maximum extent of the pack ice during the winter. This pattern is supported by observations made during the 1980's. Data gathered during the last decade show that, following the same cycle, Adélie penguins had a higher survival rate in winters with heavy pack ice. During this LTER project, investigators from six universities will define ecological processes linking the extent of annual pack ice with biological dynamics of different trophic levels within antarctic marine communities. Generally, the focus will be on yearly variations in representative populations from the marine food web (i.e., Adélie penguins, skuas, krill, and antarctic silverfish) and on mechanistic links controlling observed variations. These data will allow development of broader characterizations applicable to other large marine environments. To achieve this we will use remote sensing, annual monitoring, and a series of process-oriented research cruises to collect data at several spatial and temporal scales. Modeling will be used to link multiple spatial and temporal scales between biological and environmental components of the ecosystem. (S-010, S-013, S-016, S-028, and S-032)

Energetics of adult and larval krill (*Euphausia superba*). *Langdon Quetin and Robin Ross, University of California at Santa Barbara.* Although *Euphausia superba* (antarctic krill) is a major component of the southern-oceans ecosystem, little is known about the physiological ecology of this species. Our objective is to quantify the role of ice biota in the winter survival of krill larvae. The differences observed in the physiological conditions of larvae during the winter could lead to differences in the survival of the young-of-the-year and, consequently, the strength of any single year's class. We will study the processes underlying these differences during the early and late winter. Low food availability in the fall, after the summer phytoplankton blooms, suggests that larvae in early winter experience several months of near starvation. If an additional food source, such as ice biota found on the underside of the sea ice, did not exist, these larvae might not survive the winter. During a year of heavy ice cover, larvae found under the sea ice in late winter should have had access to this additional food source and are likely to be in better physiological condition at the end of the winter than they were at the beginning. We will compare environmental conditions in open water and under the sea ice, sampling larvae in both environments to determine their physiological condition. During two month-long cruises to the southern oceans, we will quantify nutritional contribution of ice biota to the total energy demand of krill larvae. Several significant questions about the wintering energetics of larval krill, in particular the role of ice biota in winter survival and subsequent recruitment will be addressed. (S-014)

Limits of adaptation and microbial extinction in the antarctic desert. *E. Imre Friedmann, Florida State University.* Cryptoendolithic microorganisms, which colonize the upper few millimeters of limestone rocks in the ice-free regions of Antarctica, live in an extreme environment near the absolute limit of their physiological potential. Consequently, even minor changes in the environment can trigger community death. Although light and meltwater from snow penetrate the rocks, the extremely low ambient temperatures appear to limit growth in these communities. Researchers have found that a climatic gradient spans a range of sites located in the McMurdo Dry Valleys in southern Victoria Land. By using automatic data loggers to monitor the microscale climate inside the rocks, we will quantify these environmental conditions. Computer models based on these measurements will help us to identify the exact environmental threshold—between life and extinction—for these organisms. To document how dead microbial communities degrade and form trace fossils, we will collect living and fossilized com-

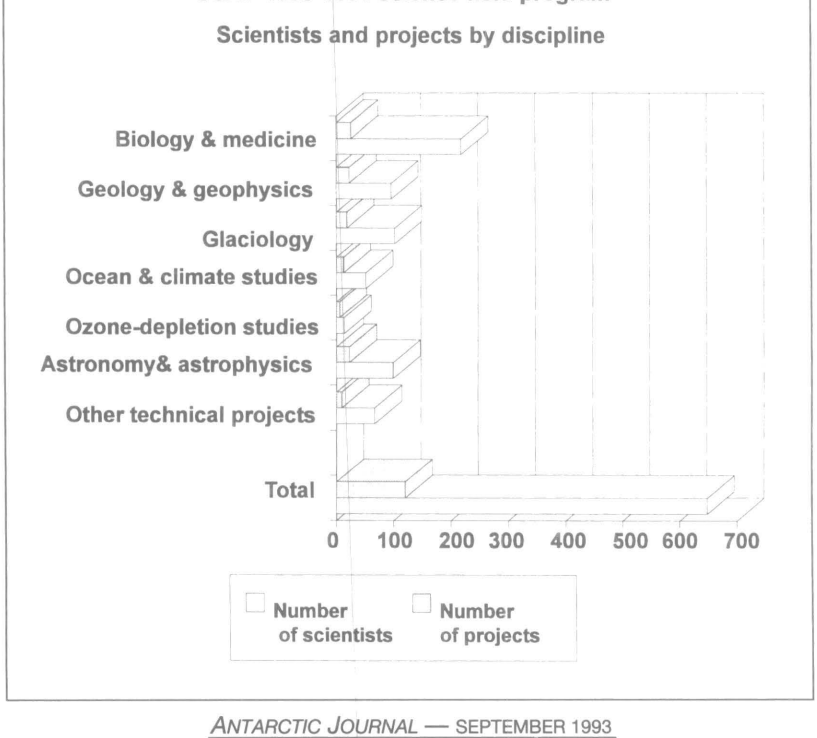
munities, using transmission electron microscopy to analyze the samples. Because the cryptoendolithic microbial ecosystem in the McMurdo Dry Valleys is thought to parallel the last stages of life on early Mars, our investigation will help other researchers to reconstruct the process of extinction of life on Mars and may suggest what form such traces of life might take on present-day Mars. (S-015)

Social structure, agreement, and conflict in groups in extreme and isolated environments. *Jeffrey C. Johnson, East Carolina University.* Our study focuses on how an environmentally extreme and geographically isolated site affects the social structure of groups as well as an individual's understanding of that structure. Working at the Amundsen–Scott South Pole Station, we will study the incidence and management of conflict and the effect that conflict has on the group structure. By collecting qualitative and quantitative data for three groups living and working at the station, we will gain understanding of group formation, status and role consensus, perceived conflict, and morale. From these data, we will develop quantitative models of group structure formation. Greater understanding of the role of group structure and cognition in the functioning of groups in isolation will complement work on health and adaptation in polar environments. It will also enable us to develop improved procedures for selecting groups of people who will live in Antarctica or other isolated environments. (S-018)

Antarctic dry valley lakes: Pathways of organic-matter production and decomposition. *Brian L. Howes and Craig D. Taylor, Woods Hole Oceanographic Institution.* In temperate regions, seasonal environmental changes and biogeochemical cycles influence freshwater-lake ecosystems. The mixing and diluting of lake water, however, can obscure the importance of some biogeochemical processes. The lakes of the McMurdo Dry Valleys sharply contrast with temperate-zone lakes but are uniquely suited for studying the internal production and degradation of organic material. They are located in one of the Earth's most arid and barren environments that has only minor amounts of inorganic matter, organic material, and nutrients. Annually, glacial meltwater forms these lakes. The seasonal cycle is simple—6 months of light and 6 months of dark—with the permanent ice cover stabilizing the environment. During the austral summer, sufficient light penetrates the ice cover to support algal and bacterial photosynthesis. This sustains a microflora population similar to temperate lakes without plant nutrients but with plentiful amounts of oxygen. Focusing on Lake Fryxell in the McMurdo Dry Valleys, we will develop an ecosystem-level understanding of the rates and pathways of carbon, nitrogen, sulfur, and water cycling. These data will be used to produce a model of the lake's carbon cycle for comparison to similar ecosystems. Specifically, we will determine the relative importance of physical versus biological processes in controlling the composition and distribution of bioactive and nonbioactive gases in dry valley lakes. We will also determine how important the rate at which the water column is cycled versus the rate of algal-mat photosynthesis is to the production of organic matter in the system and what the contribution of these processes is to the ecosystem's carbon cycle. The overall annual rate at which organic matter decomposes in the lake ecosystem will also be estimated. By understanding the processes controlling elemental cycling in this relatively simple physical environment, we hope to enhance our understanding not only of antarctic lakes but also of other aquatic systems, especially marine and estuarine sediment systems and stratified water columns. (S-020)

The chemical ecology of shallow-water antarctic marine invertebrates in McMurdo Sound. *William J. Baker and James B. McClintock, Florida Institute of Technology.* Our objective is to identify and quantify biological chemicals that affect ecological relationships among bottom-dwelling antarctic marine invertebrates. Researchers have successfully documented that biological chemicals do have a moderate influence on ecological relationships in polar communities, thus contradicting a contemporary theory that suggests that as latitude increases, the number of marine organisms using chemical defenses decreases. Extending the scope of this earlier study, we will investigate the chemical nature of defensive agents. To accomplish this, we will isolate and characterize biologically active chemicals from invertebrates that previously were found to use chemical defense mechanisms. With these data, we will be able to evaluate such roles these chemicals play as feeding deterrents, antifouling agents, or overgrowth inhibitory chemicals; determine the biological origin of these chemical excretions (metabolites) and examine the storage of defensive agents in specific tissues or mucus. This research will enhance our understanding of the significance of defense metabolites in the ecology of antarctic marine benthos. (S-022)

The ecology of nematodes in antarctic dry valleys. *Diana W. Freckman, University of California at Riverside.* Nematodes are microscopic invertebrates found in all ecosystems. They are particularly abundant in soils, living in water films surrounding soil particles. Like bacteria and other decomposers they play an



important role in nutrient cycling in soil food webs by feeding on microscopic plants and animals. This study continues our earlier study, which was the first intensive ecological investigation of nematodes in the dry valley ecosystems in Antarctica. During the 1990–1991 and 1991–1992 austral summers, we found nematodes over a wide range of dry-valley soil properties (moisture, salinity, and nitrogen and carbon content). This research will further understanding of the abundance and trophic role of nematodes by sampling them in various habitats (soil properties and microbial activity), soil formations, elevations, and locales in the dry-valleys region of southern Victoria Land. In response to harsh conditions, nematodes can assume a cryptobiotic state in which their metabolism becomes undetectable and physiological and morphological changes occur. Studies of cryptobiosis will determine the potential duration of nematode activity in this cold desert and will complement research on nematode population dynamics. We will also examine the response of nematodes and total soil microbial activity to levels of temperature, moisture, and energy in the soil. To determine total soil response, we will measure carbon-dioxide efflux and substrate-induced respiration, which is related to soil microbial biomass. The genetic diversity of populations of the dominant nematode in the dry valleys will be evaluated using molecular biology techniques. We believe that if nematodes are easily dispersed by wind, this diversity will be comparable over a wide area. (S-023)

Water-column transformations of nitrogen in a perennially ice-covered antarctic lake. *John Priscu, Montana State University.* Lake Bonney, located in the McMurdo Dry Valleys, is a permanently ice-covered lake that is divided into two distinct lobes by a narrow, shallow channel. This lake presents a special situation in which turbulence and upper trophic levels are virtually nonexistent. In this ecosystem, microbially mediated processes dominate biogeochemical reactions. Data on the nitrogen dynamics of the lake show that phytoplankton are generally nitrogen-deficient and that nitrous-oxide concentration in the chemocline of the east lobe is the highest recorded in nature. Bulk denitrification does not exist in the east lobe, and the natural abundance of nitrogen-15 in nitrate within the west lobe is the highest ever measured in an aquatic system. We believe that both ammonium and oxidized nitrogen are significant regenerated nutrients in the upper trophogenic zone. We also maintain that nitrous oxide is a product of nitrification and that, in the west lobe, bulk denitrification acts as a sink for nitrous oxide and regulates its accumulation. To address these hypotheses, we will measure microbial generation and use of ammonium, nitrite, nitrate, and nitrous oxide and determine the distribution of nitrifying and denitrifying bacteria. This study is one of the first to examine nitrogen dynamics in a system lacking top-down regulation and will provide important clues regarding global microbial nitrous oxide production and consumption. (S-025)

Foraging and distribution patterns of breeding emperor penguins in the western Ross Sea. *Gerald L. Kooyman, Scripps Institution of Oceanography, University of California at San Diego.* Because it is one of the Earth's most pristine environments, Antarctica will continue to serve as a baseline for the world. As the use of marine and terrestrial environments expands, assessing environmental quality in Antarctica will become more critical. We believe that emperor penguins can be used as a natural indicator of environmental change. These penguins, which appear to be sensitive to even small changes in the marine environment, inhabit one of the richest marine environments surrounding Antarctica. Much of their natural history is already known, and the birds living in this area most likely remain in the Ross Sea year-round. To use them as an indicator of changing environmental conditions, we need to know what types of variables will be most useful for baseline information. For the three major colonies in the Ross Sea area, we will compare foraging and distribution patterns, study hunting tactics, compare food habits and predation pressure, determine if the birds have traditional foraging areas and depths, study predator avoidance, and determine chick and egg losses. Also of interest is why some colonies are larger than others and why the only two "super" colonies (those with more than 20 chicks) are within 150 kilometers of each other in the Ross Sea. If we are successful in determining which variables have the greatest effect, we will be able to have an early-warning system that will indicate changes in the marine environment. (S-026)

Ozone diminution, ultraviolet radiation, and phytoplankton biology in antarctic waters. *Raymond C. Smith and Barbara B. Prezelin, University of California at Santa Barbara.* The biological consequences of increased ultraviolet (UV) radiation reaching the Earth's surface due to the antarctic ozone hole has recently been documented. Using direct *in situ* measurements of ultraviolet (UV) radiation and primary productivity, we estimate that ozone-related damage to phytoplankton results in a minimum of 6 to 12 percent reduction in primary productivity within the marginal ice zone of the southern oceans. We will further examine the effects of exposure to enhanced levels of UV radiation by developing a space and time climatology of spectral irradiance arriving at and penetrating the southern oceans. The magnitude and kinetics of UV-dependent production of organic carbon and UV photodamage will also be determined and analyzed in the context of a bio-optical model of primary productivity. Results will significantly enhance the prediction of changes within phytoplankton communities experiencing enhanced UV radiation and provide an empirical basis for developing models designed to assess the consequences for higher trophic levels in the antarctic food web. (S-034 and S-010)

Physiological studies of free-diving Weddell seals. *Warren M. Zapol and Robert C. Schneider, Massachusetts General Hospital.* Weddell seals *(Leptonychotes weddellii)* have certain important adaptations that enable them to dive to depths of as much as 500 meters for periods of more than 1 hour. To concentrate on mechanisms of gas transport in free-diving seals, we will use noninvasive ultrasonography to evaluate the oxygen-storage capacity of the seal's spleen and continuous laser spectrophotometry to study how oxymyoglobin stores oxygen in their skeletal muscles during free diving. We will also examine how oxyhemoglobin is diverted to the heart and brain rather than to peripheral circulation. The metabolic demands during diving will be estimated by using a velocity meter. In parallel studies, the heart rate of fetal seals will be monitored to examine how it is altered during the

mother's diving so that they can tolerate prolonged periods when oxygen is limited. (S-035)

Foraging ecology and reproduction energetics of antarctic petrels. *Wesley W. Weathers, University of California at Davis.* The feeding ecology and energetics of the cape pigeon and the snow petrel, two common surface-nesting petrels that breed in the high antarctic, will be addressed through a variety of field and laboratory techniques. Both the diet and energy requirements of adults and their offspring will be quantified. By conducting measurements over three consecutive breeding seasons, we will assess differences in feeding ecology and reproductive performance. In the field, we will determine metabolic rate of adult petrels during the incubation and chick-rearing stages of the breeding cycle using the doubly labeled water technique. Basal metabolic rates of adults will be determined from laboratory measurements of oxygen consumption and their reproductive effort expressed as the ratio of field metabolic rate to basal metabolism. To estimate foraging energy costs, we will divide foraging trips of adults into time spent resting on water and in flight. Nestling growth will be assessed from measurements of body mass, size, and composition as functions of nestling age. Nestling energy budgets will be constructed from this data. Diet of nestlings and their parents will be determined from parental food deliveries and stable isotope analysis of prey and feces. Diet information, combined with doubly labeled water measurements, will be used to calculate food consumption rates, and, hence, the trophic impact of these breeding fulmarine petrels on the surrounding marine ecosystem. (S-038)

The antarctic ice-edge bloom: Its importance to intermediate trophic levels. *Joseph J. Torres, University of South Florida, Marine Science Institute.* The antarctic ice edge as a frontal system has different implications for different trophic levels. During the summer, primary producers and microheterotrophs flourish in the meltwater lens that is created in the euphotic zone (upper levels of the ocean penetrated by light) at the retreating ice edge. By contrast any enhanced standing stocks of longer lived consumer species (with generation times of a year or more) at the ice edge must be the result of immigration or production in place. Our objective is to test the hypothesis that the summer ice-edge bloom acts as a biological magnet to concentrate metazoan consumers and as a southward moving generator, facilitating growth and reproduction in zooplankton species. Research conducted in the Scotia–Weddell seas region during the austral summer will focus on the distribution, abundance, and biological activity of zooplankton and micronekton in the upper 1,000 meters of the water column in the open-water, marginal ice-zone, and pack-ice regions of the study area. We will describe the physical environment, map the extent and activity of the ice-edge phytoplankton bloom using in vivo fluorescence, and estimate primary production. Using data from an optical plankton sampler as well as from nets and trawls, we will characterize zooplankton/micronekton community structure. Biological activity of zooplankton will be evaluated through studies of metabolic rate, grazing rate, egg-production rate, diet, and metabolic enzyme activity. The resultant data will describe zooplankton/micronekton community structure, major trophic relationships, grazing impact, and patterns of energy use for species living in the study area, clearly showing the impact of the ice-edge bloom on the intermediate trophic levels. (S-039)

The influence of pack-ice on the distribution and demography of Pygoscelis penguins. *Wayne Z. Trivelpiece, Old Dominion University.* Penguins are major predators of krill *(Euphausia superba)* and an important component of the antarctic marine food web. To understand thoroughly the structure and function of the antarctic ecosystem, biologists must have information on population dynamics, as well as the factors that regulate the size of penguin populations, especially the dominant antarctic genus—Pygoscelis penguins. The three pygoscelid penguins—Adélie *(P. adeliae)*, chinstrap *(P. antarctica)*, and gentoo *(P. papua)*—nest sympatrically on King George Island, where we have studied them for the last decade from an National Science Foundation–built field camp on the western shore of Admiralty Bay. Penguins have been banded at this site, and their breeding ecology and population biology have been studied. Results of these studies indicate that each species responds differently to winter conditions, differs in annual survival levels, and has different age and sex requirements for maintaining population levels. Our primary objectives are to determine the age-specific demographic parameters for these penguin populations and to compare these parameters with Adélie populations in different environments. (S-040)

McMurdo Dry Valleys: A cold desert ecosystem. *Robert A. Wharton Jr., University of Nevada, Desert Research Institute.* The extreme environment of the McMurdo Dry Valleys will be the focus of a long-term ecological research (LTER) project located approximately 100 kilometers east of McMurdo Station, Antarctica. The McMurdo Dry Valleys are among the most extreme deserts in the world, being subject to low temperatures, very limited precipitation, and salt accumulation. The biological systems in the valleys are relatively simple, with no vascular plants or vertebrates and very few insects. Trophic interactions and biogeochemical nutrient cycles are largely limited to microbial populations and microinvertebrates. Species diversity and abundance are low as would be predicted for such extreme environments. Despite this simplicity, complex interactions among species and between the biological and physiochemical environment exist in the lakes, streams, and soils. The obvious effects of an extreme environment coupled with the general simplicity of ecosystem structure makes the dry valleys an ideal location to study the basic relationships in the ecosystem. Two central hypotheses will be the focus of this research: (1) the structure and function of dry-valley ecosystems are primarily controlled by physical constraints, and (2) the structure and function of dry-valley ecosystems are modified by material transport. The dry-valley LTER will address these hypotheses and the five core areas of LTER research emphasis through a program of systematic environmental data collection, long-term experiments, and model development. Efforts will focus on the integration of the biological processes within and material transport between the lakes, streams, and terrestrial ecosystems in the dry-valley landscape. (S-042)

Test morphogenesis in giant antarctic foraminifera. *Samuel S. Bowser, Wadsworth Center for Laboratories and Research.* Some types of foraminiferan protozoa produce shells composed of mineral grains tightly bound by a chemically resistant, biological cement. During shell development these single-celled ani-

mals collect mineral grains from the sediment and secrete this cement in the proper amount and location to sculpt architecturally elegant structures. The high abundance of certain giant species near the New Harbor field camp at Explorer's Cove in southern Victoria Land, makes the foraminiferan community there uniquely suited for study of the specific aspects of their shell construction and related questions concerning their evolution. Focusing on a giant one-celled species allows the study of the secretion of cement in a cold-adapted marine organism without the complications of cell-to-cell and cell-to-tissue interactions common to multicellular animals. Studies using time-lapse videomicroscopy, light- and electron-microscopic cell chemistry, and gel electrophoresis will provide information on this kind of test construction at the cellular and biochemical levels of analysis. Using materials testing combined with structural modeling, we will characterize the mechanical properties of the cement. From a practical standpoint, this environmentally safe cement binds immunoglobulins and has useful material properties that may have applied biotechnological or biomedical applications. Finally, molecular genetic analyses of selected species will provide a much-needed framework for determining the evolution of this important protozoan group. This highly interdisciplinary project is made possible by new advances in biotechnology and has both basic and applied implications for a variety of fields such as medicine, molecular pharmacology, protozoan development and evolution, paleontology, engineering, and marine products chemistry. (S-043)

Effects of ozone-related increased ultraviolet-B (UV-B) fluences on photosynthesis, photoadaptation, and viability of phytoplankton in antarctic waters. *Osmund Holm-Hansen, University of California at San Diego.* Decreased concentrations of ozone in the stratosphere over Antarctica have resulted in increased levels of ultraviolet (UV) radiation in the UV-B portion of the spectrum arriving at the Earth's surface beneath the ozone hole. There is now global concern that this enhanced UV flux may cause serious harm to the marine ecosystem in the southern oceans. This project, which includes field and laboratory studies, will help to determine the effects of enhanced levels of UV-B radiation on phytoplankton and to relate such effects to overlying ozone concentrations. UV levels, as determined from the UV-spectroradiometer at Palmer Station, will be used to interpret observed biological effects, primarily on photosynthetic rates, damage to DNA with resulting loss of cell viability, and the rates and extent to which phytoplankton can minimize cellular UV damage by production of specialized protective pigments. Differences in sensitivity to UV-B among the dominant phytoplankton species or groups will also be determined. Such differences might have important consequences on the structure of the food web in antarctic waters. The data will be obtained from September through December, thus encompassing the period of maximal development of the ozone hole as well as the occurrence of the summer solstice. (S-044)

Long-term ecological research (LTER) on the antarctic marine ecosystem: Microbiology and carbon flux. *David M. Karl, University of Hawaii.* Investigators from six U.S. universities are conducting a comprehensive measurement program of ice-dominated ecosystems in the Antarctic Peninsula region near Palmer Station. This long-term project focuses on primary production, krill populations, and sea birds. It also emphasizes the development of ecosystem models that will provide a predictive capability for issues related to global environmental change. Our project focuses on the biogeochemical cycling of carbon and associated biological elements. (S-046)

Antarctic telepresence/power demonstration project. *Carol Stoker, National Aeronautics and Space Administration.* We will demonstrate the potential uses of a basic telepresence system—a system that can see but not move. This system, attached to a submersible remotely operated vehicle, will be used to map the biological, chemical, and physical characteristics of ice-covered Lake Hoare in Taylor Valley. From the data, we will develop three-dimensional profiles of temperature, light, currents, dissolved oxygen, and microbial distribution and morphology. (T-303)

Marine and terrestrial geology and geophysics

Surveying, mapping, and describing most of the geologic features in Antarctica has enabled geologists during the last 30 years to understand geology and geophysics of the region, as well as to address questions that have such broader applications as deciphering the history of the continents and evolution of Earth's tectonic plates. Now that most reconnaissance work has been completed, geologists and geophysicists are focusing on the role of the south polar region in global geodynamics, the evolutionary history of endemic marine and terrestrial biota, and Antarctica's role in the evolution of ocean circulation. Special considerations include investigating the tectonic relationship between West Antarctica and other areas of the world to learn more about Gondwana before it broke up, probing past environments through fossil data, and studying meteorites that have been uniquely concentrated on the surface of the antarctic ice sheet. On the one hand, the complex structure of the sea floor presents fundamental problems in geology and geophysics, but on the other, its sediments record in detail changes in the antarctic ice sheets, helping geologists to understand the continent's glacial history and the changes caused by the break-up of Gondwana.

Geodetic satellite tracking laboratory. *Arnold Tucker, Applied Research Laboratories, University of Texas at Austin.* At McMurdo Station, a Geodetic Satellite Observatory will be operated to collect data from the global positioning system (GPS) navigational satellites as part of the international CORE network. This network is part of the National Aeronautics and Space Administration's solid earth science program. These satellites transmit real-time precise positioning information that will be added to data from other CORE sites to provide for the production of precise GPS ephemerides, to support Earth-orbiting space missions that involve on-board GPS receivers, and to provide data for the determination of Earth orientation parameters, such as spin-axis orientation and variations in length-of-day. The laboratory will be unattended but automated to provide continuous operation. Data will be relayed to the United States via the Internet communications system. (S-051)

Aerial photography of the Convoy Range, geodetic surveys in the Ross Island area, and South Pole winter program (satellite surveying and seismology). *Jerry L. Mullins and Tony K. Meunier, U.S. Geological Survey.* Accurate maps are

essential for antarctic research and support of operational and logistical activities. They also provide a cartographic base for support of future antarctic scientific investigations and data collection. The U.S. Geological Survey (USGS) maps coverage of large portions of the continent to support the U.S. program in Antarctica. Before publishing these maps, USGS establishes geodetic control for topographic and satellite image-mapping at scales of 1:10,000 to 1:250,000. This season, USGS personnel will conduct geodetic surveys, operate global positioning system (GPS) stations at various sites in the Ross Island area, and obtain aerial photography in the Convoy Range area. The photos will be used along with the existing USGS geodetic mapping control network to complete the series of 1:50,000-scale topographic maps of the McMurdo Dry Valleys. One USGS person is scheduled to continue to operate the South Pole Station seismometers (as part of the Worldwide Standardized Seismology Network) and the ultra-long-period seismic equipment. Also at South Pole Station, USGS personnel will operate the GPS satellite continuous-tracking station. This station, in addition to supporting local U.S. Antarctic Program (USAP) survey projects, has become a part of the worldwide network of continuously operating GPS stations providing data to the international geodetic community. (S-052)

Tectonic controls on formation and evolution of Permian depositional basins in the Transantarctic Mountains, as interpreted from strata-exposed areas. *John L. Isbell, Ohio State University, Byrd Polar Research Center.* The rock strata exposed in the Transantarctic Mountains were deposited in a major foreland basin that developed adjacent to the Gondwanide mountain-forming belt during the late Paleozoic and early Mesozoic. Major geologic features in this region include a foreland basin exposed in the central Transantarctic Mountains, a possible elevated region along the foreland basin, and an intracratonic basin exposed in southern Victoria Land. The Nimrod and Byrd glaciers are located between the two stratigraphic basins. Because data from the area between the two glaciers are limited, relationships between the basins are unresolved. Additional information is needed to identify the mechanisms that controlled their development and evolution. Our sedimentologic and stratigraphic analysis will identify and correlate the strata between the central Transantarctic Mountains and southern Victoria Land, establish the nature of the Beacon stratigraphic sequence and the depositional environments of the Permian strata between the two glaciers, determine what controlled the formation and evolution of the basins, ascertain whether or not the Paleozoic elevated region exists, and identify depositional patterns for use in reconstructing the regional geography that existed before it might have been offset by the Byrd Glacier fault. (S-055)

University on the ice

To encourage young scientists in antarctic disciplines and to provide hands-on field experience, the National Science Foundation will sponsor a 4-week biology training course, "Biological Adaptations of Antarctic Organisms," in January 1994 at McMurdo Station's recently completed Albert P. Crary Science and Engineering Center. The course, which is designed for 10 students, focuses on cold adaptation, energy metabolism, and molecular genetics of antarctic organisms.

The course will feature field collections, laboratory experiments, and lectures by antarctic researchers. Themes will be

- temperature adaptations of fish (Arthur DeVries, University of Illinois),
- energy metabolism during larval development of marine invertebrates (Donal Manahan, University of Southern California), and
- osmoregulation and molecular genetics of algae (L. Goff, University of California at Santa Cruz).

The objective of the course is to provide an introduction to antarctic biology to individuals interested in conducting research in Antarctica before they begin working in this environment and to give scientists who have worked in Antarctica previously an opportunity to develop new approaches or techniques.

Solidification front instability and silicic chaos in basaltic sills. *Bruce D. Marsh, Johns Hopkins University.* Since the beginnings of igneous petrology, geologists have concluded that magmas with distinctly different compositions (bimodal magmas) can occupy the same magma chamber simultaneously. Both the close associations of certain igneous rocks (that is, granophyre and plagiogranite) with basalt and the scarcity of rocks of intermediate compositions have led petrologists to propose various processes to explain the phenomenon. Isolated observations made by many investigators suggest that possibly the inward-spreading, partially crystalline meshwork (or solidification front) along the roof of sheetlike basaltic intrusions thicken to the point of gravitational instability and begin to tear internally. Gashes and lenses open, and nearby late-stage, intervening melt is forced in to fill the potential void. This process is called solidification front instability (SFI). Our field studies focus on the diabase sills of Antarctica, some of which are perhaps the best examples of solidification front instability. We will augment these studies with experimental and analytical investigations to delineate the physics and chemistry of SFI. Similar, complementary field studies will also be undertaken at Stott Mountain, Oregon, and Zora, Pennsylvania. (S-056)

Physical weathering and abrasion in the dry valleys in Antarctica: Recovery and analysis of targets exposed for 10 years. *Michael C. Malin, Malin Space Science Systems.* The ultimate goal of this long-term project is to use information about physical and chemical weathering rates to help describe past environmental conditions in the dry valleys region of the Transantarctic Mountains. This austral summer, we will collect rock samples (abrasion targets), which have been exposed for 10 years at 10 sites in the McMurdo Dry Valleys and at one site at the Allen Hills, and document other information about site conditions. This will result in 10 years of average weathering rates for several different standard materials as a function of environmental conditions at each site. These weathering rates will be important for interpreting exposure-age dates that are used to estimate the history of ice and snow cover. (S-057)

Antarctic search for meteorites. *William Cassidy, University of Pittsburgh.* Meteorites are useful for investigating possible changes through time in the meteoroid flux at the Earth, measuring the

cosmic-ray flux in past eras, identifying events in which asteroid parent-bodies were disrupted, defining the abundances and characteristics of pre–solar-system organic molecules, and studying the origin and compositions of asteroids. During the last 2 decades, field teams from the United States and Japan, joined more recently by a consortium of European countries, have collected approximately 16,000 meteorite fragments that represent between 2,000 and 5,000 distinct falls on the ice sheet. The antarctic collection, now comparable in size to the total number of meteorites collected from all sites in the rest of the world, includes many meteorites of previously unknown types and varieties. One goal is to continue to bring these fragments to facilities in the United States where they can be analyzed, cataloged, and made available to interested researchers. We expect that many more specimens, including new lunar samples and others of possible Martian origin, will be provided. A second goal has been to understand how meteorite concentrations are related to ice-sheet dynamics. During the field season, team members will continue to study meteorite stranding surfaces in order to collect information on the relationship between exposed ice and meteorite concentrations. (S-058)

Geologic studies in the Shackleton Range, Coats Land, and Queen Maud Land, East Antarctica: A North American connection. *Ian Dalziel, University of Texas at Austin.* Geologic evidence suggests, first, that the Pacific margins of the East Antarctic and North American Precambrian cratons were once juxtaposed and, second, that as the two drifted apart during the fragmentation of a Neoproterozoic supercontinent, the Pacific Ocean was formed. The most critical and most easily tested evidence supporting this hypothesis is the apparent continuation of the northwestern boundary of the Grenville orogen of the North American craton—the Grenville front—into East Antarctica at the head of the Weddell Sea between the Shackleton Range and Coats Land, an area seldom visited and never studied in detail by American geologists. Our objective this austral summer is to begin testing this hypothesis by studying the geology, geochemistry, geochronometry, and paleomagnetism of the antarctic rocks in question. The results of these studies will then be compared with those near the Grenville front in the southwestern United States. Our field work will also include detailed stratigraphic study of the only undisturbed Neoproterozoic sedimentary sequence in the antarctic continent. (S-063)

Comparative petrologic, structural, and geochronometric investigation of high-grade metamorphic rocks in the Transantarctic Mountains. *John Goodge, Southern Methodist University.* Our objective is to develop a database from which regional metamorphic, deformation, and age relations of high-grade basement metamorphic rocks in the Transantarctic Mountains can be better understood. The rocks come from the Nimrod group in the central Transantarctic Mountains and the Lanterman Metamorphic Complex in northern Victoria Land. Improved documentation of their origin, age, and tectonic evolution are important for a thorough understanding of how the paleoantarctic craton evolved and how the supercontinent Gondwana was formed. To accomplish this, we will do detailed field geologic mapping and sampling, analyze samples for structural, microstructural, kinematic and fabric characteristics, metamorphic petrology, quantitative geothermobarometry, and uranium-lead geochronometry. (S-064)

A neodymium, osmium, lead, and strontium isotopic study of the Dufek Intrusion, Pensacola Mountains, Antarctica: Re-assessment of differentiation mechanisms in layered mafic complexes. *Samuel B. Mukasa, University of Michigan.* We will conduct an isotopic study of the layered ultramafic Dufek Intrusion. The objectives are to further understanding of igneous processes in large mafic magma chambers, accurately determine the age of the Dufek Intrusion, and assess the origin of sulfide and chromite mineralization in the intrusion. The Dufek Intrusion is part of the Karoo-Ferrar tholeiitic province, one of the largest such provinces known on Earth. This research will involve high-precision, mass-spectrometric analysis of neodymium, strontium, lead, and osmium isotopes from ultrapure fractions of minerals separated from rock samples. From the results of these analyses, we will trace compositional changes of both the liquid and solid phases during crystallization and crystal segregation processes. Lead and osmium isotopes will be used as tracers to ascertain whether sulfide mineralization results from increased silica activity associated with crustal contamination or whether it is caused by temperature changes and oxygen instability. This research generally will further understanding of the processes of magma differentiation and mineralization associated with large ultramafic intrusions, which are important sources of platinum group elements. (S-065)

Paleobotany and biostratigraphy of the Allan Hills area. *Edith L. Taylor and Thomas N. Taylor, Byrd Polar Research Center, Ohio State University.* Antarctic fossil floras and faunas are becoming increasingly more important in understanding paleoecosystems and paleoclimates of this and other high-latitude regions. During the late Paleozoic and Mesozoic, Antarctica occupied a critical position in the center of Gondwana, an important fact in understanding the distribution of past floras and migration routes into other continents. Scientists have only recently begun to collect plant and animal fossils in Antarctica; therefore, our knowledge of particular floras and their relationships to those on other Gondwana continents is still developing. We worked in the Allan Hills region of southern Victoria Land during the 1989–1990 austral summer and found this area to be unique because of the diverse types and ages of plant fossils found there. The rock strata in this region contain not only Permian and Triassic but also Jurassic fossils, which are rare in East Antarctica. Besides the more common compression/impression floras, we found permineralized peat in both Permian and Triassic rocks, as well as silicified wood. Our objective during the 1993–1994 austral summer is to collect these floras, place them in their paleoecologic and stratigraphic settings, and describe the plants in detail. These data will provide taxonomic, paleoecologic, paleoclimatic, and biogeographic information that can be compared with other better known floras in Antarctica and Gondwana. (S-068)

The Ellsworth Mountains terrane: Its origin and accretion to East Antarctica. *Margaret Rees, University of Nevada.* The work on this project will help to constrain tectonic models for the Ellsworth Mountains–Whitmore Mountains block, an important tectonic element within the collage of continental crustal blocks of West Antarctica. A proper understanding of this block is key to evaluating hypotheses about the formation or breakup of super-

continents such as Rodinia in the Neoproterozoic or Gondwana in the Paleozoic. To determine the depositional and tectonic history of this region during the late Proterozoic and the Paleozoic, we will carefully map the area geologically and collect samples for microstructural kinematic analysis, trace and rare-earth geochemical analysis, and geochronological work. The project will use argon-40/argon-39 and uranium/lead isotopic dating methods to define the absolute timing of events. (S-073)

McMurdo Dry Valleys seismograph project. *John S. Derr, Albuquerque Seismological Laboratory.* Although Antarctica has few seismographs and even fewer earthquakes, it is still very important for studying seismic events in the rest of the world because locating earthquakes, determining magnitudes, and studying the Earth's deep structure require data from all azimuths. To meet these objectives, broadband digital instrumentation is presently being installed in seismically quiet locations around the world, including Amundsen–Scott South Pole Station and the McMurdo Dry Valleys. The Vanda site was chosen, in cooperation with New Zealand, to replace the noisier Scott Base Worldwide Standard system installed three decades ago. Three-component broadband and short-period vertical instruments are placed in shallow boreholes, and data are telemetered via a relay on Mount Newall to Scott Base, where processed data are recorded. The short range objectives are to deliver useful data to Scott Base year-round and to telemeter data in near real time to the Global Data Center in Albuquerque. We hope to provide data for a wide range of seismological research as long as it is useful. (S-078)

West antarctic volcano exploration (WAVE II). *William C. McIntosh and Philip R. Kyle, New Mexico Institute of Mining and Technology.* Our project consists of detailed field and laboratory studies of Cenozoic volcanic rocks in Marie Byrd Land, Antarctica. This area, one of the Earth's largest volcanic provinces, contains important records of Cenozoic glacial-volcanic history, petrogenesis, and tectonic evolution of West Antarctica. Our objective is to extend detailed field coverage to Marie Byrd Land volcanoes, which are still known only on a reconnaissance level. Subsequent laboratory studies will include geochemical and isotopic analyses, radiometric dating, and surface-exposure dating. This international cooperative program involves earth scientists from the United States, the United Kingdom, and New Zealand. (S-080)

Mount Erebus Volcano Observatory: A pilot study for seismic, gas, and robotics surveillance. *Philip R. Kyle, New Mexico Institute of Mining and Technology.* Mount Erebus, the most active volcano in Antarctica, has been in a continuous eruptive state throughout the 20th century. The volcano is unique because it contains a persistent, convecting lava lake composed of highly alkalic anorthoclase phonolite magma. During the time that the volcano has been observed, eruptive activity from the lava lake and adjacent vents has consisted of minor strombolian eruptions that occasionally eject volcanic bombs to heights exceeding 500 meters. Recent work has also shown that Mount Erebus is an important source of aerosols in the antarctic atmosphere and most likely contributes significant quantities of chlorine, fluorine, and other trace components to the snow falling on the east antarctic ice sheet. These data have important consequences for chemists who are trying to decipher paleoenvironments from snow and ice-core analyses. Our objective is to establish the Mount Erebus Volcano Observatory at McMurdo Station. The observations from this site will expand scientific understanding of the degassing behavior of an "open vent" volcano. Measurements of sulfur dioxide taken at Mount Erebus between 1983 and 1991 are among the most extensive and detailed made at any volcano over a long period. (S-081)

Constraints on the place of Antarctica in the Cambrian world. *A.J. Rowell, University of Kansas.* This season we will collect rock samples from the Pensacola Mountains that will enable us to address the questions of how these rocks fit in with present understanding of the origin of the Pacific Ocean and subsequent history of sedimentation and tectonism along the newly formed margin of East Antarctica. Expected results will include biostratigraphic ages, uranium/lead zircon isotopic ages, and sulfur/neodymium mantle separation ages of Precambrian and Paleozoic rocks. The Pensacola Mountains occupy a significant position because they expose the last remnants of the Cambrian carbonate platform that probably extended from South Australia along the length of the Pacific-facing margin of the east antarctic craton. Stratigraphically below the Cambrian limestones is an unfossiliferous sequence of strongly deformed turbidites, widely assumed to be of Proterozoic age, and to have been deposited next to the continental margin. Although mapping in previous years established the geographic distribution of rock types in the Pensacola Mountains, precise age control of many of the stratigraphic units is lacking. These gaps in knowledge impose severe limitations on interpretations of the regional or even global significance of the geology of this isolated area. Our samples will enable us to document when the proto-Pacific Ocean was initiated in this region. (S-082)

Geologic record of late Wisconsinan/Holocene ice sheet advance and retreat from the Ross Sea. *John B. Anderson, Rice University.* Marine geological and geophysical studies of the Ross and Weddell seas continental shelves provide evidence that the ice sheet grounded near the shelf edge in these areas during the late Wisconsin and that the retreat of the ice sheet to its present position was rapid and probably episodic. Our project will establish the most recent (late Wisconsin/Holocene) history of ice-sheet advance and retreat in the Ross Sea. The objectives include (1) reconstruction of the late Wisconsin paleodrainage regime, including ice stream divides; (2) reconstruction of former grounding zone positions; (3) determination of limits of the timing of ice-sheet retreat from the shelf, and (4) acquisition of geophysical, sedimentological, and paleontological data that may indicate what environmental factors influenced the ice-sheet retreat. This is a joint effort between Rice University, the University of Colorado, and Hamilton College. Experts from various fields will collaborate with glaciologists, physical oceanographers, and climatologists, who will address the problem of ice-sheet stability and the record of climatic and glaciological change. (S-083)

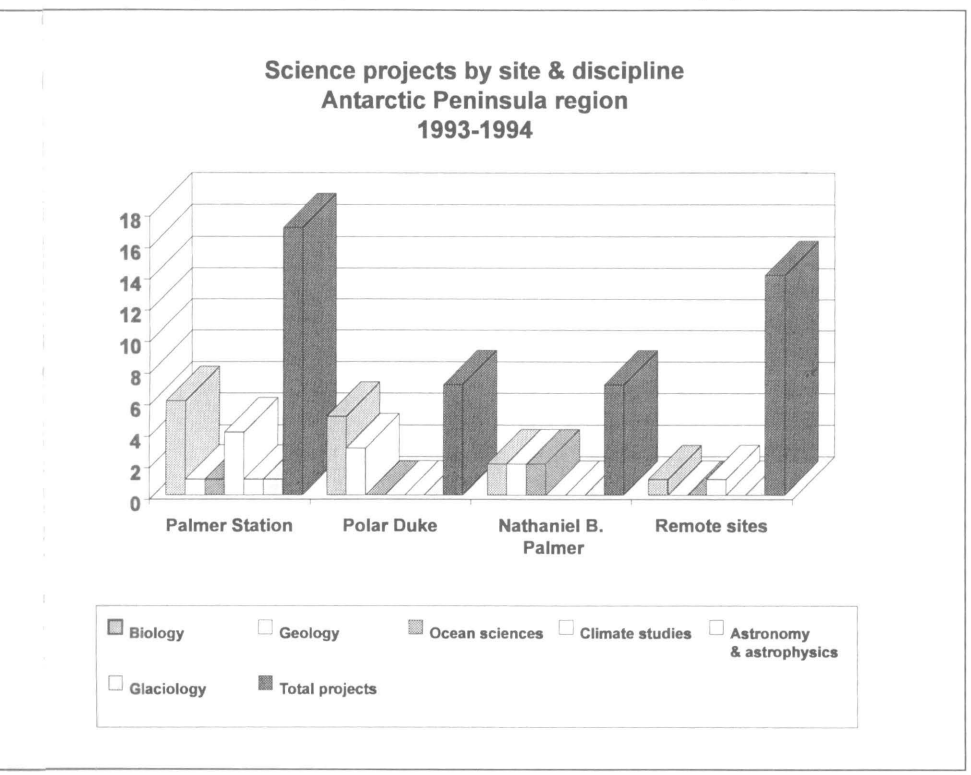
Quaternary marine stratigraphy and sedimentology of Chilean fjords and continental shelf, western Patagonia. *John Anderson, Rice University, and Jay A. Stravers, Northern Illinois University.* Our objective is to examine the dynamics of the Patagonian ice sheet during the late Wisconsin glaciation and its response to changes in the marine and terrestrial cli-

mate during the transition between the last glacial and interglacial periods. We will collect single-channel seismic-reflection data, 3.5-kilohertz profiler data, and piston cores during two marine geological cruises along the fjords and continental shelf of southern Chile. This research extends current investigations into the marine geology of the Antarctic Peninsula by including glacial-marine environments from a wider range of latitudes. The geochemistry and isotopic composition of collected cores will be analyzed to document changes in microflora (particularly diatoms) and microfauna and the palynology of some cores will be studied to refine our understanding of the relationship between terrestrial and marine paleoclimates. To enhance the applicability of litho- and seismostratigraphic studies to a broader range of Quaternary science, the project will be conducted in cooperation with Chilean geologists who are studying the sedimentary and tectonic history of the region and with other U.S. researchers who are studying marine and terrestrial paleoclimates. (S-084 and S-085)

Late Quaternary paleoclimatic history of southern Chile: Evidence from the marine record. *Amy Leventer, Byrd Polar Research Center, Ohio State University.* Southern South America provides a natural and almost continuous transition from polar to temperate climatic settings. To establish the temporal and physical links between the oceanic, atmospheric, and terrestrial systems in the Southern Hemisphere, high-resolution late Quaternary paleo-oceanographic and paleoclimatic records are essential. Our project addresses the late Quaternary marine record contained in marginal sediments of the Pacific rim of southern Chile. Diatom, foraminiferal, and mineralogic analyses of modern and late Quaternary sediments will be used to develop a high-resolution biostratigraphy and to reconstruct paleoecologic, paleo-oceanic, and paleoclimatic conditions. By comparing these results with paleoclimatic interpretations of terrestrial and ice-core data, we will have a more comprehensive understanding of the oceanic-atmospheric-terrestrial response to climate change. The objective is to develop a high-resolution, late Quaternary climate record for southern Chile that can be used to (1) establish the relationships in the timing and extent of late Quaternary glacial/climatic fluctuations between the Antarctic Peninsula and South America and (2) complete a regional framework for future paleoclimatic studies of the neoglacial history of southern South America and the Antarctic Peninsula region. (S-086)

Integrated biostratigraphy and high-resolution seismic stratigraphy of the Ross Sea: Implications for Cenozoic eustatic and climate change. *Louis R. Bartek, University of Alabama.* We will conduct an integrated seismic, sedimentologic, and paleontologic investigation of the glaciomarine stratigraphy of the Ross Sea continental shelf. To further understanding of the Cenozoic history of glaciation in the Ross Sea region, we will acquire seismic images and sediment cores of the glacial sediments and will use high-resolution, seismic-profiling data to locate regions where the Pleistocene glacial till is thin or perhaps absent. Piston coring at these locations, if the till is penetrated, will provide sedimentary records of Cenozoic depositional environments and could provide important clues to variations in the antarctic ice sheets. The seismic profiling will provide a direct record of the grounding history of the Ross Ice Shelf during the Pleistocene and will allow first-order correlations of Cenozoic sedimentary units that are represented by sediments recovered in the piston cores. The results of this investigation will provide important proxy records of the history of both the west antarctic ice sheet and the east antarctic ice sheet and this, in turn, will provide important constraints to climate models. (S-088)

IRIS: Seismology at the South Pole and Antarctic Peninsula. *Rhett Butler, Incorporated Research Institutions for Seismology, Arlington, VA.* The IRIS Global Seismographic Network (GSN) operates two stations in Antarctica: SPA at the Amundsen–Scott South Pole Station and PMSA at Palmer Station on the Antarctic Peninsula. Both SPA and PMSA provide key coverage in the Southern Hemisphere and are critical stations in the GSN. Located on the Earth's rotational axis, SPA is uniquely situated to measure long-period oscillations of the Earth without the effects of rotational splitting of modes. The Antarctic Peninsula station has a unique vantage for studies of the tectonics and seismicity of the Peninsula, South America, Scotia Sea, and Drake Passage. Near real time access to the data is important to the seismological community. IRIS is a nonprofit consortium of 81 U.S. universities that creates and manages research facilities for seismology. Currently, it provides funding to the University of California at Los Angeles to operate a long-period gravimeter at the South Pole. IRIS operates the SPA and PMSA seismic stations in cooperation with the Albuquerque Seismological Laboratory of the U.S. Geological Survey. (S-090 and S-091)



Seismic investigations of sediment stratigraphy beneath the east antarctic ice sheet. *George Thompson and Uri ten-Brink, Stanford University.* Working with geophysicists from New Zealand, we will investigate the seismicity of the sediment stratigraphy beneath the east antarctic ice sheet from the Transantarctic Mountains into the Wilkes Subglacial Basin. Our objectives are to test and provide constraints for uplift models of the Transantarctic Mountains by imaging the stratigraphic structure of the west side of the Transantarctic Mountains; to constrain models of the origin of Ferrar magmas by determining the geographic extent of this unit under the east antarctic ice sheet so that we can evaluate models of magmatism that involve mantle plume activity versus melting in response to regional rifting; and to help resolve the debate about the climatic conditions and size of the east antarctic ice sheet by determining if the Wilkes Basin contains marine sediments that could have been a source of material for the Sirius Formation, a till that contains Pliocene diatoms and that has been found at many high-altitude sites in the Transantarctic Mountains. (S-095)

Transport of hydrocarbon contaminants in ice and ice/soil systems. *Mark A. Tumeo, University of Alaska.* As human activity has increased in the polar regions, scientists and environmentalists have become more interested in how hydrocarbon contaminants are transported in freezing conditions. This 3-year study involves extensive laboratory investigation of the mechanism's driving movement in ice, snow, and frozen soil. These studies will provide specific information on the effects of matrix factors (that is, the percentage of clay and silt in soil, density/temperature in ice and snow) and of the percentage of moisture in soil on movement of the chemical components of gasoline and diesel fuel. Using the data from bench-scale studies, we will develop transport equations for a computer model for analysis and prediction of the behavior of hydrocarbons in ice and ice-soil systems. The third project component is the collection of field data at sites known to have been contaminated by fuel spills in both the Arctic and Antarctic. Data from the field studies will be used to calibrate and validate the transport model and will significantly advance efforts to understand hydrocarbon movement and fate under freezing conditions. (S-329)

Glaciology and glacial geology

Nearly 98 percent of Antarctica is covered with ice that reaches thicknesses as great as 4.8 kilometers. From ice cores, the geologic record, and the marine sedimentary record, scientists gain insight into global and regional climate and the variation of atmospheric constituents over time. By studying the continent's glacial history, glaciologists, geologists, and other scientists have learned about the timing of northern and southern glaciations, global ocean circulation, ocean boundary changes, and the dynamic response of ice to changes in the atmosphere. Deep ice cores, taken from East Antarctica provide a 160,000-year record of climate change, and data from ice-free regions enable glacial geologists to create models of ice-sheet fluctuation and soil development. Using data from radio-echo sounding and doppler-satellite positioning, glaciologists and geophysicists have measured the thicknesses of the ice sheets, learned about the internal layering of ice sheets, and determined the velocity of ice movement. Such data enables them to further their understanding of the relationship between ice and climate, the stability of Antarctica's ice sheets, and the potential impact of fluctuations in these ice sheets on global sea level.

Geophysical studies of the lateral transition zone of an active antarctic ice stream. *Charles R. Bentley, University of Wisconsin at Madison.* The manner and rate of deformation of the Earth's major ice sheets depend on a complex interplay of their geographical and climatic setting, as well as their internal dynamics. Scientists know that in the west antarctic ice sheet rapidly moving ice streams alternate with large areas of stagnant ice and that the transition between streaming and nonstreaming flow can be quite narrow. Scientists believe that in these lateral shear margins, the physical controls on ice-stream dynamics must show significant differences. This study will examine the geophysical differences between an ice stream and a stagnant ridge along the Siple Coast in West Antarctica. We will probe the ice with electromagnetic and seismic waves to infer the internal temperature and the crystalline structure of the ice, as well as the proportion of it that is old ice (Wisconsin Ice Age). The interest in these features stems from knowledge that ice-flow laws depend exponentially on temperature, that ice crystals are much less resistant to deformation in the plane of their hexagonal faces than in other directions, and that old ice may deform much more readily than ice that is geologically more recent. Measurement of radar diffraction patterns and analysis of microearthquake records can be used to determine whether the base of the ice sheet is frozen to the underlying bedrock. (S-151)

Sensitivity of the antarctic ice sheet to late Quaternary climate change. *George H. Denton, University of Maine.* We do not yet know how the antarctic ice sheet responds to climatic change; however, we can gain important insights by studying ice-sheet behavior during the last glacial cycle (the Late Quaternary). For the Ross embayment region, the accepted hypothesis is that during the glacial maximum the ice sheet expanded as sea level fell and thinned in the interior of Antarctica due to decreased accumulation. Following this, the ice sheet receded as sea level rose and thickened in the interior, thus producing the current interglacial configuration. Data from recent studies challenge this hypothesis, suggesting that only minor areal expansion occurred in the Ross embayment region during the glacial maximum. Our objective is to assess the mechanisms of antarctic ice sheet and paleoclimatic evolution through the last glacial cycle in this region. At carefully selected sites, we will examine in detail the glacial geology and isotope chronology to test these two hypotheses. By integrating this geologic record with ice-core glaciochemistry from the McMurdo dome core, we will be able to produce the first isotopically dated paleoclimatic curve for this region of Antarctica. This information will allow us to disentangle important paleoclimatic forcings of ice-sheet evolution, evaluate hypotheses of ice-age climate dynamics that require rapid, synchronous global change, and test the sensitivity of the west antarctic ice sheet to climate change. (S-156)

Borehole study of antarctic ice-stream mechanisms. *W. Barclay Kamb, California Institute of Technology.* The rapid flow of the west antarctic ice streams, which occurs probably as glacier ice slides over deformable till beneath it, has recently been studied in ice stream B

by means of boreholes drilled to the bottom. Measurements of physical conditions, materials, material properties, and motions in the basal zone can be made in such boreholes. In the 1993–1994 season, we plan to use this technique to study the ice sheet outside of ice stream B, in the Unicorn Camp. Comparison of the results with those obtained within the ice stream will further clarify the nature of the ice-streaming mechanism. We also will study how shear margins control ice stream motion, which depends crucially on the magnitude of the marginal shear stress. This will be assessed by obtaining ice core samples at depth in the Dragon Camp and testing them mechanically to determine the shear stress required to give the observed marginal shear strain rate. Drilling of shallow (approximately 400-meter) holes for measurement of ice temperature and evaluation of shear heating in the Dragon Camp will also be done in collaboration with University of Alaska investigators (S-158). The search for an understanding of the ice-stream control mechanisms is aimed at reliably assessing the possible contribution of ice streams to ice-sheet collapse brought about either by climate change or by internal instabilities. (S-157)

The measurement of temperature in the margin of ice stream B and its interpretation. *William D. Harrison and Keith Echelmeyer, University of Alaska.* We will investigate the mechanics acting at the margins of ice stream B on Siple Coast, West Antarctica. An analysis of existing temperature data near the center of the ice stream and of surface shear-strain rates at its margins indicates that strain heating in the margins should be easily measurable in holes 300 to 400 meters deep. Temperature will be measured in a line of hot-water-drilled holes that bracket one of the margins of the ice stream. These measurements will be interpreted in terms of strain heating, possible strain softening of the marginal ice, the shear stress acting on the ice stream, the history of the ice stream, and the stability of the margins. We will also seek to confirm the existence of daily variation in the vertical straining of the ice, which previously has been observed on ice stream B. (S-158)

Concentration and isotopic composition of oxygen, nitrogen, and argon in trapped gases from the Vostok ice core. *Eric Saltzman, University of Florida.* Interactions between climate and the biosphere have a profound influence on our environment. The biosphere directly affects climate by regulating the concentration of carbon dioxide and trace greenhouse gases and by influencing the hydrologic cycle. Climate has a great effect on the distribution of terrestrial ecosystems, and ocean circulation is a major determinant of oceanic production and the characteristics of marine ecosystems. The glacial-interglacial time scale is especially relevant to interactions between climate and the biosphere. Over this relatively short time interval (102,000 years), neither changing continental positions, long-term tectonic events such as mountain building, nor the evolution of the fauna and flora have influenced the climate. Rather, climate change is forced by variations in the distribution of solar radiation received on the Earth's surface and in the atmospheric concentrations of the radiatively active gases as well as by incompletely understood tectonic, climatic, biotic, or random processes. By studying Pleistocene biogeochemistry and paleochemistry, we hope to learn about climate–biosphere interactions and understand how Earth's climate will be influenced by human alteration of the planetary environment. We will experimentally determine the concentration and isotopic composition of oxygen, nitrogen, and argon in trapped air in the Vostok ice core, which preserves a 160,000-year record of the environment. (S-161)

Mass balance and ice-stream mechanics in West Antarctica. *Ian M. Whillans, Byrd Polar Research Center, Ohio State University.* The region of the ice streams in West Antarctica is the most rapidly changing portion of any ice sheet that is reliably documented. The anomaly lies with the phenomena of the fast ice streams. We seek to determine why the ice streams exist, what controls their motion, and what their current state of balance is. The field program tests the leading theory on the mechanics controlling the ice streams, provides data to refine that theory, and extends the mass-balance calculation to include more of the ice sheets. To address the mechanics of ice stream B, we will use a strain grid and precision Global Positioning System (GPS) surveying. Last year's GPS work was accurate to the 1.5-millimeter level. The Dragon Camp at the edge of ice stream B will be the base of operations. The mass balance of ice streams D and E will be investigated in cooperation with R. Bindschadler (National Aeronautics and Space Administration–Goddard Space Flight Center). Additionally, short visits are planned to South Pole and Byrd Station to service the precision mass-balance installations near those sites. (S-164)

Oxygen-isotope record from McMurdo dome and its relation to the geological climate record of the McMurdo Dry Valleys. *Pieter Grootes, University of Washington.* A climate record of the Holocene and the last part of the last glaciation will be obtained from an ice core drilled to bedrock on the McMurdo dome—a small ice dome near the head of Taylor Valley in southern Victoria Land. An age-depth model for ice flowing from the ice divide into the Taylor Glacier will be constructed from measurements of accumulation, ice thickness, and ice-flow. The model's results will be checked against time markers in the ice core. We will also compare the isotope proxy climate record with a radiocarbon-dated proxy climate record derived from perched deltas, strandlines, and moraines in the nearby dry valleys. This will improve the interpretation not only of the climatic and environmental significance of the oxygen-isotope fluctuations in ice cores but also of the history of lake-level fluctuations and ice positions in the McMurdo Dry Valleys. The results may also reveal the response of the east and west antarctic ice sheets to the glacial-interglacial temperature increase and sea-level rise. (S-167)

Evaluation of processes at polar glacier grounding-lines to constrain glaciological and oceanographic models. *Ross D. Powell, Northern Illinois University.* Our objective is to evaluate processes occurring at the grounding line of polar glaciers to develop constraints for both glaciological and oceanographic models. A submersible remotely operated vehicle (ROV) will be used to help obtain the data. We will examine the physical processes involved in the release of debris from the glacier and its dispersal in the ice-proximal marine environment. Sedimentary processes, surface sedimentary facies, and biological communities will be studied to improve interpretation of older glacial sedimentary facies. (S-170)

Reconstruction of paleotemperatures from precision borehole tempera-

ture logging: A Transantarctic Mountains transect from McMurdo (Taylor) dome to the Ross Sea. *Edwin D. Waddington, University of Washington.* As a part of this study, we will gather data to provide a direct thermal measurement of any climate warming in the Ross Sea sector of Antarctica. When combined with existing McMurdo Dry Valleys climate records and indicators, this data should provide information about past relationships in the region among such climate factors as cloudiness, air temperature, and wind patterns. To obtain the data we will log temperature as a function of depth in preexisting boreholes on a transect from McMurdo dome, through the McMurdo Dry Valleys to the Ross Sea. Paleotemperature will be derived by applying formal inverse methods to the data. The oxygen-isotope proxy record from the McMurdo dome ice core will be compared with a true thermal record to calibrate the oxygen-isotope proxy record. Vertical strain rate will be measured in an existing 130-meter dry hole to allow correction for firn compaction and ice advection. (S-171)

West antarctic glaciology—III. *Robert Bindschadler, Goddard Space Flight Center, National Aeronautics and Space Administration, and Robert Jacobel, St. Olaf College.* In recent years, the importance of the connection between ice sheets and global climate has become increasingly apparent, the most direct connection being the effect of changing ice-sheet volume on sea level. The most dramatic example of the ice sheet/climate–connection occurs when marine ice sheets collapse and cause sea level to rise rapidly as happened 12,000 years ago when the large North American ice sheets began to recede and the sea level rose 38 millimeters or more per year. Because theoretical studies indicate that marine-based ice sheets (those grounded on bedrock well below sea level) are particularly susceptible to collapse, glaciologists have focused on the stability of the west antarctic ice sheet (the largest remaining marine-based ice sheet). Since 1983, U.S. glaciologists have studied ice streams that feed into the Ross Ice Shelf along the Siple Coast in an effort to understand more clearly the status of the ice sheet as well as the processes that determine its behavior. During the 1993–1994 austral summer, we will establish a survey line across the mouths of ice streams D and E on the eastern edge of the Ross Ice Shelf. Along this 150-kilometer line, we will take ground-based and airborne radar soundings, including measurements of ice thickness along the grounding line to determine the discharge flux of the two ice streams. We will also complete surveys of velocity, accumulation rates, and temperatures at a depth of 10 meters in the catchment areas of all of the ice streams and will determine, using sequential satellite imagery, the surface velocities on ice streams D and E. (S-173)

Cenozoic glacial and climatic history of the antarctic region. *David M. Harwood, University of Nebraska.* We will map, collect, and describe fossiliferous glacial erratics from low-elevation moraines in southern Victoria Land. This season we will focus on recovering erratics from nearshore deposits of Eocene age that contain a wealth of terrestrial and marine fossils of flora and fauna. Miocene and Pliocene marine deposits are also a key target to increase the paleontologic and paleobiographic record of the Cenozoic. (S-174)

Chronology of antarctic glaciations. *Mark D. Kurz, Woods Hole Oceanographic Institution.* Through high-energy nuclear reactions, cosmic rays can produce radioactive forms of certain elements in quartz on exposed bedrock surfaces. Using accelerator mass spectrometry, researchers can determine the concentrations of these radioactive species. This information can provide valuable data on exposure times and rates of erosion for exposed bedrock surfaces. This method has been used to establish exposure ages ranging from 10,000 to 50,000 years for a variety of surfaces. The oldest exposure times that have been found are in bedrock samples from Antarctica. We will measure cosmic-ray-produced nuclides to obtain surface-exposure ages of glacial moraines. Our goal is to use this technique to define the chronology of antarctic glaciations. One priority will be to obtain new dates for the Late Wisconsin Ross Sea drift. Whenever possible, we will try to measure helium-3, beryllium-10, and aluminum-26, but in younger rocks, our measurements will emphasize detecting helium-3. (S-177)

The role of frazil ice and anchor ice in sedimentation in subpolar glacial marine environments in Antarctica. *Norman D. Smith, University of Illinois at Chicago, and Gail M. Ashley, Rutgers University.* Our project will test the hypothesis that frazil ice and anchor ice form in glacial meltwater flowing into subpolar marine water and possibly form deposits different from those formed in temperate and polar glacial environments. Although this study is a high-risk project, if successful, it will identify a significant new mechanism of sediment dispersal and lead to further understanding of ice-front processes in Antarctica. Our field-based study will consist of (1) video surveys with a submersible, remotely operated vehicle to detect frazil and anchor ice and to study the glacier terminus; (2) conductivity-temperature-depth profiles, water samples, and sediment traps to study processes of dispersal and sedimentation; and (3) bottom cores to document the record of these processes. (S-182)

Long-term trend in net mass accumulation at South Pole. *Ellen Mosley-Thompson, Byrd Polar Research Center, Ohio State University.* Climate modeling suggests that the global warming might increase atmospheric water vapor and, consequently, increase precipitation worldwide. Although increased temperatures are not likely to bring about significant melting of the antarctic ice sheet, increased precipitation could raise accumulation above the equilibrium line for nearly all of the antarctic ice sheet. This ice sheet would lower global sea level—an effect that would counterbalance increases in sea level brought about by the melting of alpine glaciers and sea ice. Thus, precipitation changes over the polar plateau will be one of several factors to consider when projecting future sea-level changes. In 1992–1993, we installed a hexagonal array of 240 poles centered on the South Pole to establish systematic, long-term monitoring of net accumulation. This year (1993–1994), our objectives are to measure the accumulation of mass over the intervening year; to drill three 18-meter cores, which will be cut into very small samples to resolve the exact depth of the known time stratigraphic-marker (Beta radioactivity) horizons in 1963–1964 and 1965; and to consider incorporating global positioning system (GPS)-based mapping of the surface elevations along the six accumulation lines. Over the next 4 years, we will continue to adjust the array and to test, refine, and standardize procedures for recording data. The goal is to develop and leave in place an optimally designed monitoring system that can be

incorporated into routine science observations at the station. (S-185)

Ocean sciences

Within the depths of the southern oceans are recorded the history of the world's oceans, changing oceanic conditions, and climate and glacial history. Also, physical and chemical processes occurring there have a central role in the composition and structure of the world's oceans. Because large-scale heat exchange at the surface overturns the water column and mixes gases in the atmosphere, these waters are a major source of the world's intermediate and deep-water masses. The Antarctic Circumpolar Current, the world's largest ocean current, affects global ocean circulation, and the annual change in sea-ice cover—from 3.0 to 20.8 million square kilometers—influences energy transfer. Ocean scientists probe the relationship between oceanic and atmospheric circulation systems and the physical basis for biological productivity; determine the dynamics of the formation and distribution of water masses, sea ice, and currents; and investigate the relationship between the southern oceans and climate.

An experimental study of tropospheric sulfur chemistry in Antarctica. *Harald Berresheim, Georgia Institute of Technology.* The objective of this project, a systematic field study of atmospheric sulfur chemistry in the antarctic troposphere, is to obtain a comprehensive database for estimating the potential impact of dimethylsulfide (DMS) emissions on the climate of Antarctica and, by extension, the global climate. Approximately 80 to 90 percent of the aerosol mass deposited on the antarctic ice sheet consists of fine particles of non-seasalt sulfate. Scientists believe that these particles are formed by gas-to-particle conversion involving biogenic sulfur gases emitted from the southern oceans. Some antarctic phytoplankton species emit large quantities of DMS, which is subsequently oxidized by the hydroxyl radical, forming sulfuric acid as one of the end products. Sulfuric acid in the atmosphere may condense to form nanometer droplets or become condensed on pre-existing aerosol particles; these phase transitions form non-seasalt sulfate, which is then precipitated onto the ice sheet. We will trace these processes by directly measuring 20 sulfur-containing species, as well as the aerosol and condensation nuclei size distribution. Field measurements will be made at Palmer Station during two austral summer months in the 1993–1994 and 1994–1995 seasons. Recently developed highly sensitive techniques will be applied to the antarctic troposphere for the first time. Using the resulting information we will assess the relative importance of the reaction pathways of individual chemicals, which will further understanding of the marine biogenic sulfur record in antarctic ice cores with respect to past climate changes. It will also provide a model database for estimating the sensitivity of the present climate of Antarctica to volcanic or human-caused sulfur pollution and the effect of such pollution on the ultraviolet radiation regime. (S-210)

Oceanography of the Amundsen and Bellingshausen seas. *Stanley S. Jacobs, Columbia University, Lamont-Doherty Earth Observatory.* Upwelling warm, deep water covers the Amundsen and Bellingshausen seas ice shelves and delivers significant amounts of heat to the sea ice and ice shelves at the edges. The regional precipitation is heavy, historically maintaining a perennial ice cover. Within the last few years, however, satellite images have shown that the ice has been receding dramatically and that large areas of open water remain through the winter in sectors that earlier had been ice-covered. These irregular ice distributions are likely to have been accompanied by altered surface water properties and possible changes in the deep vertical circulation. There are indications that the conditions favoring a reduction in the sea ice may migrate westward toward the Ross Sea and may have already contributed to a gradual warming over recent decades on the western side of the Antarctic Peninsula. This project will be the first systematic oceanographic study of the continental shelves of the two seas. It will include temperature and salinity profiling, water sampling for ocean chemistry, and continuous precision bathymetry. The project will use the research vessel *Nathaniel B. Palmer* for two cruises: one in the late austral summer 1993–1994 and another in September and October 1994 to observe late winter conditions. (S-211)

Cloud condensation nuclei: A link between oceanic sulfur and climate at Palmer Station, Antarctica. *Vinod K. Saxena, North Carolina State University.* Our objective is to obtain quantitative cloud condensation nuclei (CCN) data at Palmer Station, Antarctica, using a CCN spectrometer designed by the principal investigator. The project is integrated with a study of tropospheric sulfur chemistry to examine the climatic negative feedback mechanism involving atmospheric CCN and the emission of dimethylsulfide (DMS) from oceanic phytoplankton. DMS is oxidized and converted to CCN in the atmosphere, thus increasing marine stratus clouds. Because it reflects a greater proportion of the incoming solar radiation, this increased cloud cover is hypothesized to produce large-scale atmospheric cooling. The net cooling and the reduced solar radiation at the surface reduce the oceanic phytoplankton population and the rate of DMS emission. The remote location of Palmer Station and the establishment of the 2-year study of atmospheric sulfur chemistry offer a unique opportunity to study not only quantitative relationships between CCN and DMS but also the relationships of these compounds with other transient and stable sulfur compounds such as non-seasalt sulfates, methane sulfonate, and sulfuric acid, as well as dry aerosols and seasalt particles. (S-212)

Sea-ice physics-structural characteristics, development, and synthetic-aperture-radar (SAR) signatures in the Pacific sector of the southern oceans. *Martin Jeffries, Geophysical Institute, University of Alaska.* We will examine snowcover characteristics on sea-ice floes, ice-floe thickness, and sea-ice physical properties and structural characteristics in the Ross Sea in the late austral winter 1994 to define more clearly how sea-ice types vary by geographical location, the processes in the antarctic ice pack that are deforming it, and large-scale thermodynamics and heat-exchange processes of the ice-covered southern oceans. Specific sea-ice characteristics will be related to the synthetic-aperture-radar (SAR) signatures observed from the Japanese JERS 1 satellite. These include snowcover characteristics (depth, temperature, density, and stable isotopic composition; and structural characteristics of ice (amounts of different ice types such as snow ice, frazil, platelet, and congelation ice). Because different ice types result from variations in the conditions under which the ice forms, we will gain a better understanding of sea-ice

parameters and their geophysical controls by integrating observations and SAR data analysis with modeling studies. This analysis will also be useful in defining the kind of air-ice-ocean interactions that can be studied using SAR data, and will have broader relevance and application to atmospheric, biologic, and oceanic investigations of the southern oceans. (S-286)

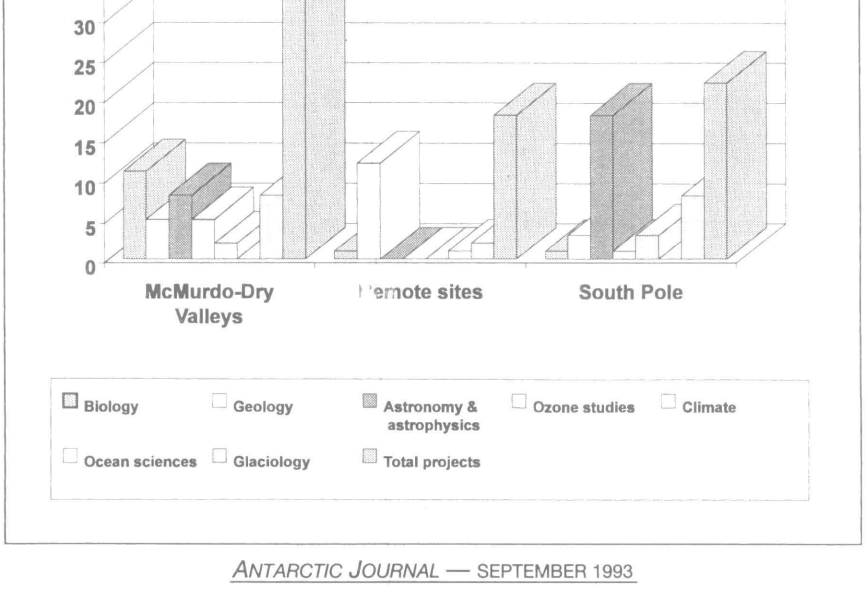
Climate studies

Global climate affects and is affected by Antarctica's climate regime. This regime, the world's largest and most intense, also has a key role in long-term climate variability. During this century, scientists have studied regional climate regimes and unique aspects of the continent's weather. From this research, they have come to understand the major seasonal features of atmospheric circulation, the radiation and energy balances, the nature of katabatic winds, and the transport of gases and aerosols. Continuing these investigations, scientists are studying the interaction of solar radiation with snow and ice surfaces and its effect on the energy budget that controls the continent's climate, the relationship between events and conditions in the antarctic atmosphere and global climate phenomena, and the region's role in global climate change.

Observational and modeling studies of episodic events in the south polar atmospheric boundary layer. *John J. Carroll, University of California at Davis, and William D. Neff, Wave Propagation Laboratory, Environmental Research Laboratory, National Oceanic and Atmospheric Administration.* The surface heat budget in polar regions is important to general circulation as well as to the rate at which snow and ice accumulates, melts, and evaporates. In Antarctica, the components of this budget vary greatly, with significant differences that are not related to local levels of solar radiation. Differences, for instance, in the surface temperature during the polar night can vary between –70°C and –40°C in less than 24 hours. Because warming is highly correlated with increased wind speed, such warming events may be caused by enhanced turbulent transfer of heat downward through the atmospheric boundary layer coupled with decreasing radiative cooling. During the 1993–1994 austral summer, we will study the dynamics of the stable atmospheric boundary layer, focusing on the importance of intermittent and episodic forcing mechanisms that determine the structure and energy transfer within the lowest layers of the antarctic troposphere. We selected Amundsen– Scott South Pole Station as the site for this project because of its reliably stable boundary-layer, smooth air-snow interface, and lack of a diurnal solar cycle. Of particular interest is the effect on boundary-layer structure and surface fluxes of heat and momentum due to time-varying pressure gradients, horizontal temperature advections, and mesoscale divergence patterns. We are using modern remote-sensing wind and temperature-profiling instruments to collect data on those phenomena and their effect on boundary-layer structure and surface fluxes. Numerical simulation models will be used to analyze the data and interpret the observed events. (S-203)

Installation of a wind profiler at the Peruvian antarctic station Machu Picchu, King George Island. *Ben B. Balsley, University of Colorado.* We will construct, install, and operate a monostotic very-high-frequency (VHF) wind-profiling radar at the Peruvian station on King George Island. Similar wind profilers have operated successfully in other remote areas in the western equatorial Pacific and in equivalent polar latitudes in Alaska. The system will provide nearly continuous measurement of the total wind vector through the troposphere and lower stratosphere and is capable of expansion to make observations of the horizontal wind in the region from 70 kilometers to 100 kilometers altitude. The project will be carried out cooperatively with the Peruvian antarctic program. (S-205)

Biogeochemistry of carbon and silica on the antarctic shelf: Particle flux and taxonomic studies. *Robert Dunbar, Rice University.* The antarctic deep sea and continental shelf environment is a major repository for silica accumulation in the global ocean and dominates the global silica budget. The Ross Sea is a particularly anomalous area in which large amounts of biogenic silica are accumulating in modern sediments, although the surface production rates are generally below the global average. Moreover, the usual similarity between the oceanic silica and carbon cycle does not appear to hold in the waters around Antarctica, where the two cycles are decoupled, in that the rate of particulate carbon deposition in the modern sediment is very low. Between 1989 and 1991, we used moored instruments and made direct observations during a series of transects by the *Polar Duke* in the Ross Sea to document the production, vertical transport, dissolution, and deposition processes. The vertical flux and dissolution rates were measured by deploying time-series sediment traps at two depths on each of three moorings for a period of 14 months. Used in conjunction with transmissometers and current-meter arrays, these moorings allow us to measure and characterize both vertical and horizontal fluxes of particulate matter during a complete



annual cycle of production and sedimentation. This austral summer our field work, which is part of a coordinated study of the biogenic silica and organic-carbon cycling in the water column and the sediments of the Ross Sea, will extend our earlier investigation of the vertical flux and the rate of dissolution of biogenic silica in the water column. As part of this effort, we will recover one sediment trap that was redeployed for an additional 2 years, finish analyzing all water-column and sediment-trap samples that are currently in hand, and produce a synthesis of all project data sets in conjunction with the other investigators cooperating in this project. (S-216)

Chlorine- and bromine-containing trace gases in Antarctica. *R.A. Rasmussen, Oregon Graduate Institute for Science and Technology.* Our objective is to collect air samples year-round at Palmer Station to investigate seasonal trends in trace-gas concentrations. The samples are analyzed at the Institute for a number of trace components, especially chlorine- and bromine-containing gases. These trace constituents, which come from both natural and manmade sources, can alter the Earth's climate. They have even been implicated in the chemical processes that contribute to the austral-spring depletion of the ozone layer over Antarctica. Our work will contribute to a better understanding of the buildup of trace constituents, particularly those of high-latitude marine origin. (S-254)

South Pole monitoring for climate change. *Eldon Ferguson, Amundsen–Scott South Pole Station, Climate Monitoring and Diagnostics Laboratory, and James T. Peterson, Palmer Station, Environmental Research Laboratories, National Oceanic and Atmospheric Administration.* The National Oceanic and Atmospheric Administration (NOAA) Climate Monitoring and Diagnostics Laboratory team will continue long-term measurements of trace atmospheric constituents that influence climate. Four scientists will work at the South Pole Station observatory during the 1993–1994 austral summer, and two NOAA personnel will winter to measure carbon dioxide, water vapor, surface and stratospheric ozone, wind, pressure, air and snow temperature, atmospheric moisture, and other trace constituents from the station's clean-air facility. These measurements are part of NOAA's effort to determine and assess the long-term buildup of global pollutants in the atmosphere. The measurements will be used for time-series analyses of multiyear data records that focus on stratospheric ozone depletion, transantarctic transport and deposition, interplay of the trace gases and aerosols with solar and terrestrial radiation fluxes on the polar plateau, the magnitude of seasonal and temporal variations in greenhouse gasses, and the development of polar stratospheric clouds over Antarctica. Other objectives of our research are to determine the rate at which concentrations of these atmospheric constituents change and to examine their sources, sinks, and budgets. Working with climate modelers and diagnosticians, these data will be used to determine how the rate of change of these parameters affects climate, particularly by including them in climate model studies. In support of this project, Palmer Station personnel also will collect carbon dioxide samples. (S-257A and S-257C)

Operation of an aerosol sampling system at Palmer Station. *Gail dePlanque and Colin G. Sanderson, Environmental Measurements Laboratory, U.S. Department of Energy.* In March 1990, a team from the U.S. Department of Energy installed a surface-air sampling station at Palmer Station to measure manmade radionuclides, generate data messages, and transmit these data through National Oceanic and Atmospheric Administration satellites to Department of Energy receiving stations. As part of a global array of automated stations, the sampling station in Antarctica fills a significant gap in this vital global data set. (S-275)

Antarctic automatic weather stations: Operation and research. *Charles Stearns and George Weidner, University of Wisconsin at Madison.* Although satellites provide invaluable information on antarctic weather, surface data are needed for verification and situations when the satellite data is minimal. Automatic weather stations measure surface pressure, air temperature, wind speed and direction, and, at some sites, humidity. The data are transmitted to polar orbiting satellites and are rebroadcast and stored for later interrogation by ground stations. The data from the weather stations are used to study the barrier wind along the Transantarctic Mountains, vertical motion and sensible and latent heat flux from the

Alternative energy sources arrive in Antarctica

Windmills standing sentinel across the sound from McMurdo Station symbolize the National Science Foundation's U.S. Antarctic Program's (USAP) growing commitment to energy efficiency. A mix of wind turbines, solar panels, and a fossil-fuel generator powers the USAP's state-of-the-art communications system on barren Black Island. In the past, all McMurdo residents had to share a single phone line, but now a remotely operated satellite earth station furnishes them with reliable telephone and computer links to the rest of the world.

The Black Island facility, about 20 miles from McMurdo Station, can be reached only by helicopter or traverse across the Ross Ice Shelf—the surface trip takes about 2 days. Environmental conditions also are extreme at the site—with wind speeds as great as 280 kilometers per hour and temperatures dropping below –51.06°C at times. However, USAP selected it as the site for an unmanned station to provide year-round access to satellite communications because Mount Erebus blocks McMurdo Station's "line of site" to the communications satellite.

The earth station runs all summer solely on wind and solar power. It provides access to Internet at 192 kilobits per second—greater capability than that offered by many U.S. institutions, according to USAP's electrical engineer Patrick Smith. The facility, at a site with minimal interference from other radio "noise," also enhances high-frequency communications with science field parties, aircraft, the U.S. station at geographical South Pole, and other locations.

USAP is harnessing alternative energy at other sites as well. In southern Victoria Land's McMurdo Dry Valleys, remote field camps are beginning to employ solar panels for heating and power. At Amundsen–Scott South Pole Station, plans are underway for new laboratories that will be heated almost completely by solar energy serving as a visionary prototype for future stations at the South Pole.

Ross Ice Shelf, warm west winds flowing from the Beardmore and Byrd glaciers, katabatic flow in East Antarctica, and mesoscale systems around the South Pole; for establishing long-term climate records at selected sites; and for the 1993–1994 field season, for studying the meteorology of the west antarctic/Siple Coast region. Data from the automatic weather stations are also used in support of aircraft operations in Antarctica. (S-283)

Antarctic Meteorology Center. *Charles Stearns, University of Wisconsin at Madison.* The Antarctic Meteorology Center will be one of three research centers in the Albert P. Crary Science and Technology Center at McMurdo Station. The center will be a resource for meteorological research and improved operational synoptic forecasting. It will use a Man-Computer Interactive Data Access System, a versatile computer-based system for organizing, manipulating, and integrating environmental data. This system will capture the flow of meteorological information from polar orbiting satellites, automatic weather stations, station synoptic observations, and research projects. The center will also receive environmental data, such as weather forecasts, from sources outside Antarctica and act as a repository for existing archived databases. During phase I, which will begin during the 1993–1994 austral summer, we will install and operate work stations that can manipulate and display data, using the existing satellite-imagery acquisition system. Phase II will consist of the acquisition and integration of a system that will provide data collection, display and archiving, scientific applications, network communications, and remote-user access. (S-283B)

Ozone-depletion studies

Since 1986, U.S. investigators have studied and monitored the changes occurring in the ozone layer above Antarctica. Although they agree that chlorine, produced by manmade chlorofluorocarbons, is a key element in the chemical reactions that break down stratospheric ozone thus depleting the amount of ozone above Antarctica each austral spring, the role and impact of atmospheric phenomena, climate dynamics, and other atmospheric aerosol compounds remain unclear. How do dynamic processes of the upper atmosphere influence the depletion? What physical properties of polar stratospheric clouds enhance the chemical reactions that destroy ozone? What other aerosol compounds contribute to the process? Answers to these and other questions are critical not only for understanding the antarctic and arctic atmosphere but also for determining the effects on global climate.

Lidar monitoring of polar stratospheric clouds. *Alberto Adriani, Institute for Atmospheric Physics.* In cooperation with the U.S. Antarctic Program, Italian scientists will make laboratory-based lidar observations of polar stratospheric clouds (PSCs) above McMurdo Station. These data add to the available information concerning the annual springtime depletion of ozone in the antarctic stratosphere and enhance scientific understanding of the role of PSCs in the depletion process. (S-107)

***In situ* measurements of polar stratospheric clouds, condensation nuclei, and ozone in the springtime antarctic stratosphere.** *Terry Deshler, University of Wyoming.* To gain more information about the annual springtime depletion of the stratospheric ozone above Antarctica, we will continue to make balloonborne measurements of the ozone, polar stratospheric cloud particles, and condensation nuclei above McMurdo Station. The principal cause of the ozone depletion is the interaction of chlorine with ozone, and polar stratospheric clouds have a major role in the chemistry that frees elemental chlorine from reservoir gases, hydrochloric acid, and chlorine nitrate. Once freed, the chlorine is available for photocatalytic destruction of ozone at sunrise. However, scientific knowledge on the formation and physical state of stratospheric-cloud particles in the polar stratosphere is limited. This project should improve our understanding of these clouds, which are key to the ozone-destruction process. (S-131)

Ultraviolet and visible spectroscopy at three polar sites. *Ryan Sanders, National Oceanic and Atmospheric Administration.* Over 5 years at McMurdo, personnel from the Aeronomy Laboratory of the National Oceanic and Atmospheric Administration will make ground-based visible and ultraviolet spectroscopic measurements of stratospheric column abundances of ozone, nitrogen dioxide, nitrate radial, chlorine dioxide, and bromine monoxide. The simultaneous measurements of these gases and their seasonal and daily variations are valuable for studying polar ozone holes and the photochemistry responsible for the destruction of the stratospheric ozone layer, particularly in the presence of volcanic aerosols from the eruption of Mount Pinatubo. Data from McMurdo will be augmented by data collected at other polar sites, such as Palmer Station, Antarctica, and Sondre Stromfjord, Greenland. (S-136)

Field observations of stratospheric trace gases in support of the Upper Atmospheric Research Satellite mission. *Robert L. DeZafra, State University of New York at Stony Brook.* Our objective is to make millimeter-wavelength radio measurements of stratospheric gases (ozone, nitrous oxide, and chlorine monoxide). These microwave-emission measurements, to be made at McMurdo Station, will provide "ground truth" for similar spectrometer measurements made by the Upper Atmospheric Research Satellite launched by the National Aeronautics and Space Administration during the late summer of 1991. (S-137)

Measurement of stratospheric trace gases by millimeter-wave spectroscopy for an annual cycle at the South Pole. *Robert L. DeZafra, State University of New York at Stony Brook.* In January 1993, we installed a ground-based, millimeter-wave spectrometer at Amundsen–Scott South Pole Station, where it will remain until December 1993. While in place, the spectrometer is recording abundances and cycles of atmospheric trace gases—measurements that are important to the scientific understanding of the annual antarctic "ozone hole." Our equipment measures chlorine monoxide, ozone, and nitrous oxide. Chlorine monoxide is a unique product resulting from the destruction of ozone by chlorine, and nitrous oxide is valuable as a tracer of the dynamics of the atmosphere. Measurements of these gases will be useful for determining the degree of stratospheric subsidence during the polar winter. They are also important to understanding how manmade chemicals, such as chlorofluorocarbons, can cause global change. (S-137B)

Lidar experiment at South Pole. *Giorgio Fiocco, Università La Sapienza, Rome, Italy.* Our lidar is designed to take vertical profiles of the upper stratosphere. From this data, we are able to infer the molecular and aerosol concentration of air and, under some conditions, measure such parameters as atmospheric temperature.

This information is useful in climatic studies, is relevant to studies of atmospheric radiation, structure, and composition, and may aid understanding of ozone-depletion mechanisms. This is a cooperative project between the U.S. and Italian antarctic programs. (S-256)

Astronomy, astrophysics, and upper atmosphere studies

Antarctica provides researchers with a unique platform from which to probe Earth's near- and far-space environment, the nature of stellar and solar activity, and solar-terrestrial effects on humans and the environment. Because the continent encompasses a range of geomagnetic latitudes, scientists can study the plasmapause (the internal magnetospheric boundary), the magnetospheric cusp, and the auroral zone. At the geographic South Pole, astronomers and astrophysicists are taking advantage of the site's unique climate and geographic features to probe the mysteries of the Universe's beginning and the nature of cosmic background radiation. Data from these studies and others help describe how solar energy enters the outer terrestrial environment and reaches the atmosphere, how disturbances associated with the transfer of energy propagate to and affect the planet's surface, and how matter in the Universe formed into galaxies and clusters of galaxies.

Operation of an extremely-low-frequency/very-low-frequency radiometer at Arrival Heights, Antarctica. *Robert A. Helliwell and A.C. Fraser-Smith, Stanford University.* During the 1993–1994 field season, we will continue to operate an extremely-low-frequency and very-low-frequency (ELF/VLF) radiometer at Arrival Heights, a radio-quiet site on Ross Island. The radiometer, one of seven systems that Stanford University operates at different sites around the world, measures the intensity of electromagnetic radiation, making possible the study of wave-particle interactions in the magnetospheric plasma (low-energy ionized gas that permeates the magnetosphere). These systems make possible measurements of naturally occurring radio noise in the 5 hertz to 30 kilohertz range. With the resulting data, we will develop a long-term climatology of natural background noise, a climatology that will further understanding of coherent radiation from magnetospheric plasma. The results can also be applied to communications, remote sensing of magnetospheric plasma, and modification of the magnetosphere and ionosphere by wave-induced particle precipitation. (S-100)

Magnetometer data acquisition at McMurdo and Amundsen–Scott South Pole stations. *Louis Lanzerotti, AT&T Bell Laboratories, and Alan Wolfe, New York City Technical College.* Magnetometers installed at sites in both polar regions have provided measurements of the magnitude and direction of variations in the Earth's magnetic field. This project focuses on these variations from magnetometers installed at conjugate sites in the Northern and Southern Hemispheres—specifically, at McMurdo and Amundsen–Scott South Pole stations, Antarctica; Iqaluit, Northwest Territories, Canada; and Sondre Stromfjord, Greenland. Using these systems, we gather data on the coupling of the interplanetary medium into the magnetospheric cusp region and the causes and propagation of low-frequency hydromagnetic waves in the magnetosphere. Because of unique climatic conditions at the South Pole, we are also able to correlate optical measurements with particle precipitation and with hydromagnetic-wave phenomena recorded by the magnetometer. (S-101)

High-latitude magnetic pulsation studies in Antarctica and the Arctic. *Roger L. Arnoldy, University of New Hampshire.* We will continue to collect and analyze data from magnetic pulsation sensors located at high-geomagnetic-latitude stations in the Arctic (Sondre Stromfjord, Greenland) and Antarctica (McMurdo and Amundsen–Scott South Pole stations). The measured pulsations, which range in frequency from a few millihertz to a few hertz, are used in conjunction with similar data acquired from a number of satellites. They are vital to scientists' understanding of the mechanism by which energy is transferred from the solar wind to the Earth's magnetosphere. (S-102)

Antarctic auroral imaging. *Stephen Mende, Lockheed Palo Alto Research Laboratory.* To explain the processes producing the auroral phenomena, scientists need to understand the connection between individual auroras and various regions of the magnetosphere. In the past, space satellites have explored the magnetosphere in some detail and the energetic particle plasma content of the magnetosphere have been mapped. By knowing how the magnetospheric and the auroral regions are configured and connected, researchers will be able to determine the nature of the mechanisms responsible for generating auroral forms, specifically auroral arcs. Amundsen–Scott South Pole Station is uniquely situated for optical observations of polar aurora. The 24-hour austral winter night allows us to monitor aurora continuously for daily movements and responses to geomagnetic activity and to the changing conditions of the interplanetary medium. An intensified optical, all-sky imager, operating in two parallel wavelength channels—4,278 and 6,300 Ångstroms—will be used to record digital and video images of aurora. The objective is to investigate the electrodynamics of the polar cap and cleft regions by measuring auroral-precipitation patterns and interpreting the results in terms of coordinated observations of magnetic, radio-wave absorption images and high-frequency, coherent-scatter radar measurements. Through this investigation, we hope to learn about the sources and energization mechanisms of auroral particles and other forms of energy inputs into the high-latitude atmosphere. (S-104)

Very-low-frequency sensing of thunderstorms and radiation-belt coupling. *U.S. Inan, Stanford University.* Recent research results suggest that lightning and thunderstorms may have a major role in the precipitation of trapped particles from the radiation belts surrounding the Earth. By using ground- and satellite-based observations, researchers have established that detectable lightning-induced electron precipitation and associated ionospheric disturbances do occur. Such precipitation is evidence of a fundamental mechanism of coupling between the magnetosphere-ionosphere system and the middle atmosphere. Our project focuses on the bursts of precipitation that lightning discharges induce at middle to low latitudes. The results help us determine the role of lightning and thunderstorms in relation to magnetospheric electrons and the way in which the atmosphere, ionosphere, and magnetosphere are coupled. To study this phenomenon, we will use the intensifications of ionospheric density that it produces. These are detected as amplitude and phase perturbations on very-low-frequency, low-frequency, and middle-frequency radio signals that spread out along geomagnetic field lines. Scientists know

that such measurements are a powerful and possibly unique ground-based tool for detecting particle precipitation at mid and low latitudes. While working at Palmer Station, technicians will take simultaneous high-resolution measurements of the amplitude and phase of subionospheric very-low-frequency, low-frequency, and middle-frequency signals to determine the spatial distribution, temporal signatures, and magnetic conjugacy of lightning-induced precipitation. (S-106)

South Pole air shower experiment (SPASE) for gamma-ray astronomy at ultra-high energy. *Thomas Gaisser, University of Delaware.* Since cosmic rays were discovered early in this century, scientists have sought to determine their point of origin. Although they initially believed that cosmic rays were energetic electromagnetic radiation, more recent data have shown that they are electrically charged particles—mainly hydrogen nuclei and more particularly protons. The South Pole air shower experiment (SPASE) is a large, phased array of scintillation detectors, which were installed at the South Pole Station in 1988 to search the southern sky for astrophysical sources of ultra-high energy (100-gigaelectronvolt) gamma rays. The circumpolarity of the sky over Amundsen–Scott South Pole Station makes this site one of the few from which continuous observations can be made for 200-teraelectronvolt gamma rays from a large number of x-ray binaries and related compact objects—potential emitters of primary cosmic rays. The station's location allows scientists to search for regularities of what are, in the few cases confirmed to date, somewhat episodic sources. SPASE has been upgraded every year since its installation; however, data obtained from the system have not provided convincing evidence for a strong source, a result that is consistent with similar detectors elsewhere. This year SPASE will be modified to operate in conjunction with the antarctic muon and neutrino detector array (AMANDA) with the goal of seeing the same high-energy events with both detectors to understand more clearly the nature and origin of the primary cosmic rays that produce such events. (S-109D)

Antarctic neutral thermosphere and mesosphere dynamics and thermodynamics. *Gonzalo Hernandez, University of Washington.* Ground-based optical measurements of the motions and temperatures of the upper atmosphere—at heights greater than 70 kilometers—are being made at Amundsen–Scott South Pole Station to investigate the dynamic behavior of this region of the atmosphere. The station's unique location at the rotational pole makes it possible to measure atmospheric motions at all local times (that is, longitudes) and, therefore, directly determines the zonal wavenumber mode of the observed traveling wave motions by a simple measurement of the longitudinal phase progression of these waves. The measurements indicate that the atmosphere near the poles strongly favors zonal wavenumber 1 modes for motions and wavenumber 0 modes for temperature (and density). Confirmation of these recent findings is now in progress. The dynamics of the higher latitude neutral

International, multidisciplinary projects focus on southern oceans

GLOBEC

The International Global Ocean Ecosystems Dynamics (GLOBEC) program has identified the southern oceans as a potential research area. This region has also been endorsed by the U.S. GLOBEC program. To date, two workshops have been held under the auspices of the U.S. and International GLOBEC programs to define scientific questions, objectives, and potential sites for a southern oceans GLOBEC program. The results and recommendations from these workshops are published as part of the International and U.S. GLOBEC report series.

Information on the International GLOBEC program can be obtained from Elizabeth Gross, Executive Director, SCOR; Department of Earth and Planetary Sciences; The Johns Hopkins University; Baltimore, MD 21218; Omnet: E.Gross.SCOR.

Information on the U.S. program can be obtained from U.S. GLOBEC; Scientific Steering Committee Coordinating Office; Division of Environmental Studies; University of California; Davis, CA 95616-8576; Omnet: T.Powell.

JGOFS

One of the long-range goals of the Joint Global Ocean Flux Study (JGOFS) is to improve understanding of the processes that control the fluxes of carbon and other biogenic elements within the southern oceans and between the oceans, the atmosphere, the sea floor, and the continental boundaries. Another goal is to develop the ability to predict on a global scale the response of these processes to changes in climate.

JGOFS and its national programs have recognized that the conducting studies in the southern oceans is vital to meet these goals. The carbon fluxes of the southern oceans are an important component of the global cycle, highly susceptible to perturbation, and less well understood than fluxes in less remote areas of the southern oceans.

Seven nations, including the United States, have plans for JGOFS activities in the southern oceans. Cruises and time-series projects were begun in 1991 and will continue through 1995 for the first phase of the international program. Plans are being made for a second phase during 1996–1998. A report prepared by the JGOFS Southern Ocean Planning Group, *The JGOFS Southern Ocean Study*, was published in 1992 and is available from Elizabeth Gross, Executive Director, SCOR; Department of Earth and Planetary Sciences; The Johns Hopkins University; Baltimore, MD 21218.

U.S. JGOFS plans for studies in the southern oceans focus on a transect along 170°W from the Subtropical Convergence near New Zealand to the Ross Sea. The field program is expected to begin in 1994, with the bulk of the work to be done during the 1995–1996 and 1996–1997 field seasons.

The U.S. JGOFS Planning Office has published two reports that describe the scientific rationale, issues, objectives, and plans for the proposed U.S. studies in the southern oceans: *The Southern Ocean Process Study Planning Workshop Report* (1992) (report 16) and *The Southern Ocean Process Study Science Plan* (1993) (report 17). Both are available from U.S. JGOFS Planning Office; Woods Hole Oceanographic Institution; Woods Hole, MA 02543.

thermosphere in the Southern Hemisphere are scientifically interesting because of the larger separation between the rotational and the geomagnetic poles than its counterpart in the Northern Hemisphere. This results in different atmospheric dynamic response in the two hemispheres to the influences of solar ultraviolet radiation, magnetospheric convection, and solar-wind particle effects. The results of this investigation, as solar activity changes, will further understanding of this important atmospheric region. (S-110)

Riometry in Antarctica and conjugate regions. *Theodore Rosenberg, University of Maryland.* We will use imaging, broad-beam riometers, and optical photometers to study the processes of energy transfer from the solar wind to Earth's magnetosphere and ionosphere at high geomagnetic latitudes. The emphasis will be on understanding the ionospheric signatures of dayside auroral phenomena associated with particle entry into the cusp and boundary layers, as well as the nightside substorm effects associated with the magnetotail and plasma sheet. Three imaging riometers—located at Amundsen–Scott South Pole Station, Sondre Stromfjord, Greenland, and Iqaluit, Northwest Territories, Canada (the magnetic conjugate to the South Pole)—will provide continuous, simultaneous, conjugate measurements of polar auroral phenomena. (S-111)

Polar experiment network for geophysical upper-atmosphere investigations (PENGUIN). *Theodore Rosenberg, University of Maryland.* A consortium of U.S. and Japanese scientists plans to use a network of automatic geophysical observatories (AGOs) established on the polar plateau and equipped with suites of instruments to measure magnetic, auroral, and radiowave phenomena. The first AGO was deployed in December 1992. Three more AGOs are to be deployed during the 1993–1994 field season and the two final AGOs during the following field season. These arrays of instruments, along with measurements made at select manned stations, will be used to study the energetics and dynamics of the high-latitude magnetosphere on both large and small scales. The research will be carried out along with in situ observations of the geospace environment by spacecraft, in close cooperation with other nations working in Antarctica and in cooperation with conjugate studies performed in the Northern Hemisphere. (S-112)

Cosmic microwave background radiation studies at the South Pole. *Philip M. Lubin, University of California at Santa Barbara.* We will continue to improve our previously successful measurements of the cosmic microwave background radiation (CMBR) variations from a site near Amundsen–Scott South Pole Station. The CMBR is radiation left over from a few hundred thousand years after the creation of the Universe. Any variations in the CMBR reveal the structure of the early Universe. Because the leftover radiation now reaching the Earth is in a wavelength range in which water vapor is absorbed, these measurements must be taken from places such as the South Pole, where the atmosphere is extremely cold (and therefore dry), or from above the atmosphere. (S-115)

Solar and heliosphere studies with antarctic cosmic-ray observations. *John Bieber, University of Delaware.* Neutron monitors in Antarctica provide a vital three-dimensional perspective on the anisotropic flux of cosmic rays that continuously bombards Earth. At the McMurdo and South Pole stations year-round observations will continue for cosmic rays with energies in excess of 1 billion electronvolts. With these data, we will advance understanding of a variety of fundamental plasma processes occurring on the Sun and in interplanetary space. Neutron-monitor records, which began in 1960 at McMurdo and 1964 at the South Pole, will play a crucial role in efforts to understand the nature and causes of cosmic-ray and solar-terrestrial variations occurring over the 11-year sunspot cycle, the 22-year Hale cycle, and even longer time scales. At the other extreme, we will use new methods to study high time-resolution (10-second) cosmic-ray data to determine the three-dimensional structure of turbulence in space and to understand the mechanism by which energetic charged particles scatter in this turbulence. (S-120)

All-sky-camera measurements of the *aurora australis* from Amundsen–Scott South Pole Station. *Frank T. Berkey, Center for Atmospheric and Space Sciences, Utah State University.* Amundsen–Scott South Pole Station, located at the south geographic pole, is a unique platform from which to undertake measurements of the polar ionosphere. Due to the configuration of the geomagnetic field in the Southern Hemisphere, the station is situated in such a way that dayside auroras can be viewed for several hours each day. Research has shown that they are caused by precipitation of low-energy particles, which enter the magnetosphere by means of the solar wind. Since 1965 data have been acquired at the South Pole using a film-based, all-sky-camera system. Using advanced technology, we can now digitize photographic images and process large amounts of information automatically. Besides continuing to acquire 35-millimeter photographic images with all-sky-camera system, we will collaborate with Japanese researchers to analyze part of the data with an all-sky-camera processing system developed at Japan's National Institute of Polar Research. This system displays data in a geophysical coordinate framework and analyzes images over short and long intervals not possible with individual photographic images. The data will be used to investigate dayside auroral structure, nightside substorm effects, and polar-cap arcs. These studies can also be used to obtain further insight into the physics of the magnetosphere, the convection of plasma in the polar cap, and solar winds in the thermosphere. (S-122)

Observation of very-high-energy gamma-ray sources from the South Pole. *Robert M. Morse, University of Wisconsin at Madison, and James A. Gaidos, Purdue University.* Although cosmic radiation was discovered more than 75 years ago, its origin remains a mystery. Gamma rays represent only a small fraction of the total cosmic-ray flux, but they spread out undeflected from their sources to the Earth. The dominant, electrically charged component, however, is deflected by magnetic fields. To identify sources of cosmic radiation, which, according to some theories, may have been created by a modest number of supernovas, we will install an atmospheric Cherenkov telescope near the South Pole. The telescope consists of an array of parabolic mirrors with photomultiplier tubes at their foci that can detect light from very-high-energy interactions in a small amount of atmosphere. The geographic South Pole is an ideal location for this because we can see a single object through a constant thickness of

atmosphere for extended periods. At mid-latitude sites, observations are limited to a few hours of viewing at a time. (S-125)

Low-frequency/high-frequency programmable frequency receiver to the antarctic automatic geophysical observatories. *James W. LaBelle, Dartmouth College.* For decades, intermittent ground observations have given tantalizing hints that the Earth's high-latitude ionosphere emits radio waves in the low-frequency to high-frequency band (0.15–9.6 megahertz). Rocket and satellite observations in the upper regions of the ionosphere and magnetosphere commonly indicate the existence of these terrestrial radio signals, particularly in the lower portion of this frequency range. Theoretical studies have indicated that some of these emissions should penetrate the ionosphere and be detectable at ground level, but ground-based recordings are needed to study this much-neglected radio band, to confirm these theories, and to provide insight into auroral emission and wave-propagation processes. The unmanned automatic geophysical observatories (AGOs) are ideal for this effort because these frequencies can be greatly affected by human-produced transmissions, which are generally minimal in Antarctica. Because the AGOs can be installed at locations remote from antarctic stations, interference from radio transmissions is even less of a problem. To gather data about this poorly understood frequency band, our study will use a programmable low-frequency/high-frequency receiver, an array of small ferrite-rod antennas, a power subsystem, and data-compression software deployed at two automatic geophysical observatory sites. (S-128)

Spectroscopic and interferometric studies of airflow and auroral processes in the upper atmosphere over Amundsen–Scott South Pole Station. *G.G. Sivjee, Embry-Riddle Aeronautical University.* Our project focuses on the physical, dynamic, chemical, and atomic-molecular processes occurring in the upper atmosphere above Antarctica—particularly the mesopause, thermosphere, and ionosphere. The long, dark winters at Amundsen–Scott South Pole Station will be used for more extensive observations of semidiurnal, diurnal, and longer-period disturbances propagating through the mesopause. We hope to compare our data from the station with similar data from our stations in the Arctic (where topological and meteorological conditions are different from those in Antarctica) to assess the contributions of these factors to the mesopause disturbances. (S-129)

The AMANDA project: The antarctic ice sheet as a high-energy detector. *Robert M. Morse, University of Wisconsin at Madison.* The antarctic muon and neutrino detector array (AMANDA) consists of sensitive photomultiplier tubes that have been imbedded about 1 kilometer deep in the antarctic ice sheet near the South Pole. This array makes it possible for us to use the ice itself as a Cherenkov detector for high-energy neutrinos of astrophysical origin that have passed through the Earth. AMANDA is also able to detect neutrinos produced in the atmosphere near the North Pole and, therefore, can be used to measure neutrino properties. Neutrino astronomy has, to date, been limited to detection of solar neutrinos and one brief burst from the supernova that appeared in the Large Magellanic Cloud in February 1987. Very recently several new sources of high-energy gamma rays, which may also be neutrino sources, have been discovered by the Compton Observatory satellite and, most significantly, the atmospheric Cherenkov telescope on Mount Hopkins, Arizona. We also believe that there should also be many detectable neutrino sources that are not detectable as gamma rays or any other wavelength of electromagnetic radiation, because of intervening matter. Only now is it becoming technically feasible to build neutrino telescopes. As one of the first generation of such instruments, AMANDA promises to be a large contributor to a new branch of observational astronomy. (S-130)

Center for Astrophysical Research in Antarctica. *Doyal A. Harper, University of Chicago.* Infrared and submillimeter astronomy has the potential of answering some major questions about the formation of the Universe, including questions concerning (1) inconsistencies in cosmic microwave background radiation, (2) the processes by which stars form from interstellar gas, (3) ic formation of planets, (4) the nature of primeval galaxies, and (5) the uneven distribution of matter and energy in the early Universe. Making use of Antarctica's unique physical characteristics and geographic location, the University of Chicago—collaborating with Princeton University, AT&T Bell Laboratories, and other institutions—has established the Science and Technology Center for Astrophysical Research in Antarctica. The center provides an observatory at the South Pole with instruments designed to probe the far reaches of the Universe and to support three significant experiments. ASTRO (Antarctic Submillimeter Telescope and Remote Observatory, John Barley, University of Colorado) uses a 1.7-meter-diameter submillimeter telescope, surveying the galactic plane, the galactic center, and the Magellanic Clouds. SPIREX (South Pole Infrared Explorer, Mark Hereld, University of Chicago), which makes use of an existing 60-centimeter-diameter, near-infrared telescope, explores the potential of the South Pole as an infrared site and is surveying primeval galaxies and brown dwarf stars. This spectral window is also located within a "hole" in the celestial background and may afford the most sensitive view of light from galaxies formed in the early Universe. At this wavelength, a South Pole telescope will be more sensitive than the Hubble telescope and 200 times more sensitive than a ground-based telescope at a mid-latitude site. COBRA (Cosmic Background Radiation Anisotropy, Mark Dragovan and Jeffrey B. Peterson, Princeton University) searches for and maps anisotropies in the cosmic background radiation at sufficient sensitivity to test current theories of the origin of the Universe. The South Pole center will enable these researchers and others to make measurements at wavelengths that are usually hampered by the absorption and emissions of the Earth's atmosphere. Because of the near absence of water vapor in the atmosphere above the polar plateau, the infrared skies are clearer and darker than anywhere else on the Earth. These unique environmental conditions overcome not only the diurnal variations in temperature that lead to atmospheric noise and wind at higher latitudes but also much of the infrared background radiation. The elevation of the antarctic plateau significantly reduces the atmospheric path that the light must traverse. The geographic singularity of a polar site also allows a unique opportunity to reduce systematic errors in searches for cosmic microwave background anisotropies. All of these factors will combine to improve the observing conditions by a

factor of 10 to 100. (S-132A, S-132B, S-132C, S-132D, and S-132E)

Long-duration ballooning—Launch and telemetry support. *David Stuchlik, Wallops Flight Facility, National Aeronautics and Space Administration.* In support of astrophysical and astronomy projects, we will launch (from Williams Field near McMurdo Station), track, provide telemetry support for, and recover large high-altitude helium balloons. (S-145)

Antarctic long-duration balloon flight for the JACEE collaboration. *R.J. Wilkes, University of Washington.* The goals of our experiment are to measure the cosmic-ray energy spectrum and composition in the ultra-high energy range (approaching 1,015 electronvolts) and also to study nuclear interactions at these energies, which are beyond the capabilities of any accelerator. Long-duration balloon (LDB) flights and analyses of passive cosmic-ray composition measurements will be conducted by a collaborative group known as JACEE (Japanese-American cosmic-ray emulsion-chamber experiment), which includes nearly 35 senior scientists at 11 institutions from the United States, Japan, and Poland. The JACEE group is expected to launch 20 such LDB flights over the next 10 years. (S-147)

Infrared measurements in the Antarctic. *Frank J. Murcray, University of Denver, Colorado.* This project uses an infrared (IR) interferometer to monitor some of the trace constituents in the atmosphere above South Pole and McMurdo stations, Antarctica. Two types of measurement will be taken: an absorption mode to detect the Sun's IR radiation shining through the atmosphere and an emission mode to detect radiation emitted by the atmospheric gases themselves. The first technique will allow very sensitive measurements of a number of trace constituents, especially during the local springtime when the antarctic ozone hole is forming. The second technique is less sensitive but does allow critical measurements during the long, dark polar night when the chemical interactions that set the stage for the springtime ozone depletion take place. The compounds to be measured include hydrogen chloride, nitric acid, chlorofluorocarbon-11 and -12, nitrous oxide, methane, ozone, and chlorine nitrate. All play a role in the ozone hole and several of them are also important greenhouse gases. This project is a precursor to establishing an antarctic network to detect stratospheric change. If we can establish a similar station at a site on the high polar plateau (such as Dome C), the Network for Detection of Stratospheric Change station (established by the National Oceanic and Atmospheric Administration and the National Aeronautic and Space Administration to detect long-term trends in stratospheric change) will allow similar measurements to be made from there. (S-148)

Foundation awards of funds for antarctic projects, 2 March 1993 to 31 May 1993

Following is a list of National Science Foundation antarctic awards made from 2 March to 31 May 1993. Each item contains the name of the principal investigator or project manager, his or her institution, a shortened title of the project, the award number, and the amount awarded. If an investigator received funds from more than one program in the Office of Polar Programs (OPP), the award is listed under the heading for each program with funds provided by that program listed first and the total award amount in parentheses. If an investigator received a joint award from more than one Foundation program, the antarctic program is listed first, and the total amount of the award is listed in parentheses. Award numbers for awards initiated by the Office of Polar Programs contain the prefix OPP; those by the Division of Earth Sciences, the prefix EAR; and those by the Division of Atmospheric Science, the prefix ATM.

Biology and medicine

Kennicutt, Mahlon C. Texas A&M University, College Station, Texas. The grounding of the *Bahia Paraiso:* A continuing study of the environmental fate of an antarctic oil spill. OPP 90-22346. $61,091.

Kieber, David J. State University of New York, Syracuse, New York. Photochemistry of antarctic waters in response to changing ultraviolet radiation fluxes. OPP 93-12767. $106,503.

Kiefer, Dale A. University of Southern California, Los Angeles, California. A simulation model of southern ocean air-sea-ice interactions. OCE 92-21791. $159,297.

Kinkle, Brian. University of Cincinnati, Cincinnati, Ohio. Cold adaptations of carbon metabolism in antarctic phototrophic microorganisms. OPP 90-17739. $46,607.

Miller, Gary D. University of New Mexico, Albuquerque, New Mexico. Dynamics of subcolonies in the Adélie penguin. OPP 93-11804. $32,693.

Mopper, Kenneth. Washington State University. Pullman, Washington. Photochemistry of antarctic waters in response to changing ultraviolet radiation fluxes. OPP 92-21598. $88,000.

Siniff, Donald B. University of Minnesota, Minneapolis, Minnesota. Antarctic pack-ice seals: A workshop. OPP 93-12289. $14,000.

Smith, Raymond C. University of California, Santa Barbara, California. Ozone diminution, ultraviolet radiation, and phytoplankton biology in antarctic waters. OPP 92-20962. $320,000.

Swanberg, Neil R. Woods Hole Oceanographic Institution, Woods Hole, Massachusetts. Intergovernmental Personnel Act mobility assignment. OPP 92-17615. $89,509.

Tipper, Ronald C. Joint Ocean Institutes, Inc., Washington, DC. Field research on antarctic seabirds: A workshop. OPP 93-12110. $75,049.

Trivelpiece, Wayne Z. Old Dominion University, Norfolk, Virginia. Influence of pack ice on the distribution and demography of Pygoscelis penguins. OPP 91-21952. $13,942.

Wharton, Robert A. University of Nevada, Reno, Nevada. McMurdo Dry Valleys: A cold desert ecosystem. OPP 92-11773. $549,048.

Marine and terrestrial geology and geophysics

Bartek, Louis R. University of Alabama, Tuscaloosa, Alabama. Integrated biostratigraphy and high-resolution seismic stratigraphy of the Ross Sea: Implications for Cenozoic eustatic and climatic change. OPP 92-20848. $75,000.

Brozena, John M. Naval Research Laboratory, Arlington, Virginia. Corridor aerogeophysics of the southeastern Ross transect zone: Airborne gravity. OPP 90-20576. $110,021.

Coakley, Bernard J. University of Wisconsin, Madison, Wisconsin. Airphoto survey and characterization of raised marine features in Victoria Land, Antarctica. OPP 92-19737. $9,916.

Duebendorfer, Ernest M. Northern Arizona University, Flagstaff, Arizona. The Ellsworth Mountain terrane: Its origin and accretion to East Antarctica. OPP 93-12040. $51,987.

Dwoskin, Gary E. National Academy of Sciences, Washington, DC. Study on airborne geophysics. OPP 93-06279. $7,500 ($25,000).

Harwood, David M. University of Nebraska, Lincoln, Nebraska. Integrated biostratigraphy and high-resolution seismic stratigraphy of the Ross Sea: Implication for Cenozoic eustatic and climatic changes. OPP 92-20854. $19,996.

Kurz, Mark D. Woods Hole Oceanographic Institution, Woods Hole, Massachusetts. Acquisition of a noble gas mass spectrometer. EAR 92-20479. $25,000 ($246,112).

Rees, Margaret N. University of Nevada, Las Vegas, Nevada. The Ellsworth Mountains terrane: Its origin and accretion to East Antarctica. OPP 92-20395. $47,376.

Scherer, Reed. Ohio State University, Columbus, Ohio. Mixed diatom assemblages in Pliocene to Recent diamictons of the central Ross Sea and the Siple Coast, West Antarctica. OPP 92-20413. $99,693.

Sloan, Lisa C. University of California, Santa Cruz, California. Polar climates, clouds, and seasonality in the Paleogene. EAR 93-12104. $15,000 ($35,000).

Stravers, Jay A. Northern Illinois University, De Kalb, Illinois. Quaternary marine stratigraphy and sedimentology of Chilean fjords and continental shelf, western Patagonia. OPP 91-19194. $16,223.

Webb, Peter-Noel. Ohio State University, Columbus, Ohio. Integrated biostratigraphy and high-resolution seismic stratigraphy of the Ross Sea: Implications for Cenozoic eustatic and climate change. OPP 92-20844. $33,442.

Webb, Peter-Noel. Ohio State University, Columbus, Ohio. Workshop—antarctic stratigraphic drilling—Cape Roberts project. OPP 93-12733. $15,335.

Zinsmeister, William J. Purdue University, West Lafayette, Indiana. Molluscan transition across the Cretaceous/Tertiary boundary and early Paleocene recovery, Seymour Island, Antarctica. OPP 90-17246. $30,000.

Ocean and climate studies

Andreas, Edgar L. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire. Atmospheric boundary layer measurements on the Weddell Sea drifting station. OPP 90-24544. $86,309.

Berresheim, Harald. Georgia Technical Research Corporation, Atlanta, Georgia. An experimental study of tropospheric sulfur chemistry in Antarctica. OPP 92-18952. $175,565.

Bromwich, David H. Ohio State University, Columbus, Ohio. Continued study of the boundary layer dynamics over West Antarctica. OPP 92-18949. $199,992.

Carleton, Andrew M. Indiana University, Bloomington, Indiana. Structure and evolution of southern ocean mesocyclones using multiple satellite systems. OPP 92-19446. $53,989.

DeMaster, David J. North Carolina State University, Raleigh, North Carolina. The preservation and accumulation of biogenic silica and organic carbon in a high-latitude environment: The Ross Sea. OPP 92-21769. $77,864.

Domack, Eugene W. Hamilton College, Clinton, New York. Research Undergraduate Institute: Depositional processes and stratigraphy of antarctic fjords and ice shelf environments. OPP 89-15977. $13,559.

Dunbar, Robert B. Rice University, Houston, Texas. Biogeochemistry of carbon and silica on the antarctic continental shelf: Particle flux and taxonomic studies. OPP 92-21578. $60,763.

Jacobs, Stanley S. Lamont-Doherty Earth Observatory, Palisades, New York. Oceanography of the Amundsen and Bellingshausen seas. OPP 92-20009. $186,058.

Jeffries, Martin O. University of Alaska, Fairbanks, Alaska. Sea ice physical-structrual characteristics: Development and synthetic aperture radar signature in the Pacific sector of the southern oceans. OPP 91-17721. $7,926.

Katsaros, Kristina B. University of Washington, Seattle, Washington. Structure and evolution of southern ocean mesocyclones using multiple satellite systems. OPP 92-18810. $70,722.

Leventer, Amy. Ohio State University, Columbus, Ohio. Biogeochemistry of carbon and silica on the antarctic continental shelf: Particle flux and taxonomic studies. OPP 93-10975. $21,175.

Martinson, Douglas G. Lamont-Doherty Earth Observatory, Palisades, New York. A physical/chemical/biological simulation model of southern ocean air-sea-ice interactions to predict carbon source/sink intensity. OPP 92-22304. $149,843.

Nelson, David M. Oregon State University, Corvallis, Oregon. Cycling of biogenic silicia in the water column of the Ross Sea. OPP 92-21425. $87,482.

Nittrouer, Charles A. State University of New York, Stony Brook, New York. The preservation and accumulation of biogenic silica and organic carbon in a high-latitude environment: The Ross Sea. OPP 93-10165. $108,098.

Padman, Laurence. Oregon State University, Corvallis, Oregon. Upper ocean current and temperature measurements in the western Weddell Sea. OPP 90-24695. $3,850.

Saxena, Vinod K. North Carolina State University, Raleigh, North Carolina. Cloud condensation nuclei: A link between oceanic sulfur and climate at Palmer Station, Antarctica. OPP 92-18538. $90,893.

Shen, Hayley H. Clarkson University, Potsdam, New York. Wave and pancake ice interactions. OPP 92-19165. $8,500.

Wendler, Gerd. University of Alaska, Fairbanks, Alaska. Katabatic winds in eastern Antarctica. OPP 90-17969. $7,796.

Astronomy, aeronomy, and upper atmosphere physics

Baker, Kile B. Johns Hopkins University, Baltimore, Maryland. SHARE—Southern Hemisphere auroral radar experiment. OPP 92-21343. $26,500.

Bering, Edgar A. University of Houston, Houston, Texas. Balloonborne studies of the ionosphere and magnetosphere above Antarctica. OPP 90-19567. $5,250.

Erlandson, Robert E. Johns Hopkins University, Baltimore, Maryland. Comparison of simultaneous ground-satellite observations of electromagnetic ion cyclotron waves. OPP 92-24511. $10,000 ($111,500).

Harper, Doyal A. University of Chicago, Chicago, Illinois. A center for astrophysical research in Antarctica. OPP 89-20223. $55,000 ($184,527).

Helliwell, Robert A. Stanford University, Stanford, California. Active and passive very-low-frequency wave-particle interaction experiments from Siple Station, Antarctica: Mechanism and diagnostic application. OPP 92-21395. $42,578 ($132,578).

Inan, Umran S. Stanford University, Stanford, California. Very-low-frequency remote sensing of thunderstorm and radiation belt coupling to the ionosphere. OPP 90-20687. $10,000.

Lubin, Philip M. University of California, Santa Barbara, California. Cosmic microwave background radiation studies at the South Pole. OPP 92-21468. $356,843.

Morse, Robert M. University of Wisconsin, Madison, Wisconsin. Observation of very-high-energy gamma-ray sources from the South Pole (GASP). OPP 92-21768. $65,000.

Papen, George C. University of Illinois, Champaign, Illinois. Rayleigh and sodium lidar studies of the troposphere, stratosphere, and mesosphere at the Amundsen–Scott South Pole Station. OPP 92-19898. $120,000.

Petit, Noel J. Augsburg College, Minneapolis, Minnesota. Research Undergraduate Institute: Automatic geophysical observatory data support and distribution. OPP 92-19799. $22,748.

Sivjee, Gulamabas G. Embry-Riddle Aeronautical University, Daytona Beach, Florida. Spectroscopic and interferometric studies of airglow and auroral processes in the upper atmosphere over South Pole Station. OPP 92-18557. $100,471.

Tinsley, Brian A. University of Texas, Richardson, Texas. Analysis of South Pole electric field data: Nature of variations related to sector boundary crossings. OPP 92-08937. $10,000.

Wilkes, R.J. University of Washington, Seattle, Washington. Long duration balloon flight for the Japanese-American cosmic ray emulsion chamber experiment (JACEE) collaboration. OPP 92-20316. $135,000.

Weather at U.S. stations

Feature	May 1993			June 1993			July 1993		
	McMurdo	Palmer	South Pole	McMurdo	Palmer	South Pole	McMurdo	Palmer	South Pole*
Average temperature (°C)	–25.8	–2.4	–57.8	–25.0	–5.0	–61.9	–22.6	–4.3	
Temperature maximum (°C)	–13.2	4.5	–35.1	–13.4	1.8	–30.9	–10.0	3.4	
(date)	(23)	(7)	(31)	(17)	(13,15)	(1)	(28)	(11)	
Temperature minimim (°C)	–37.9	–11.0	–73.0	–38.9	–15.3	–75.9	–33.2	–13.4	
(date)	(31)	(12)	(8)	(11)	(24)	(28)	(29)	(4)	
Average station pressure (mb)	985.5	984.8	675.8	979.9	990.1	675.7	974.7	989.0	
Pressure maximum (mb)	1003.1	1016.1	692.3	1009.9	1021.0	696.0	1001.5	1019.0	
(date)	(13)	(13)	(13)	(9)	(9)	(2)	(28)	(2)	
Pressure minimum (mb)	960.0	961.9	663.1	954.4	963.0	661.7	936.8	948.8	
(date)	(24)	(21)	(23)	(18)	(15)	(23)	(20)	(12)	
Snowfall (mm)	160	544	Trace	678	961	Trace	152.4	157.0	
Prevailing wind direction	35°	Northeast	20°	66°	Southwest	70°	45°	Northeast	
Average wind (m/sec)	5.2	6.3	6.2	6.7	5.2	5.7	6.2	7.8	
Peak wind (m/sec)	33	37	19	37	28	14	36	37	
(date, direction)	(22, 220°)	(17, 20°)	(10, 360°)	(2, 140°)	(15, 40°)	(30, 360°)	(25, 200°)	(24, 10°)	
Average sky cover	5.6	8.5	3/10	7.0	8.5	2/10	6.7	8.1	
Number of clear days	9.0	1.0	20.0	2.0	1.0	23.0	7.0	2.0	
Number of partly cloudy days	10.0	6.0	7.0	13.0	6.0	4.0	6.0	7.0	
Number of cloudy days	12.0	24.0	4.0	15.0	23.0	3.0	18.0	22.0	
Number of days with visibility less than 0.4 km	1.3	—	7.0	6.5	—	4.0	3.2	—	

*South Pole data were not received for July 1993. These will be included in a later issue.

Prepared from information from the stations. Locations: McMurdo 77°51'S 166°40'E, Palmer 64°46'S 64°3'W, Amundsen–Scott South Pole 90°S. Elevations: McMurdo sea level, Palmer sea level, Amundsen–Scott South Pole 2,835 meters. For prior data and daily logs, contact the National Climate Center, Asheville, North Carolina 28801.

Glaciology

Baker, Ian. Dartmouth College, Hanover, New Hampshire. In situ synchrotron x-ray topographic studies of polycrystalline ice. OPP 92-18336. $3,625.

Bentley, Charles R. University of Wisconsin, Madison, Wisconsin. Geophysical studies of the lateral transition zone of an active antarctic ice stream. OPP 92-20678. $223,457.

Dwoskin, Gary E. National Academy of Sciences, Washington, DC. Study on airborne geophysics. OPP 93-06279. $7,500 ($25,000).

Kamb, Barclay. California Institute of Technology, Pasadena, California. Constraints on the antarctic ice-streaming mechanism from studies of subglacial sediment cores. OPP 92-19279. $110,137.

Kurz, Mark D. Woods Hole Oceanographic Institute, Woods Hole, Massachusetts. Acquisition of a noble gas mass spectrometer. EAR 92-20479. $25,000 ($246,112).

Lea, David W. University of California, Santa Barbara, California. Antarctic ice core records of oceanic emissions: Sulfur, selenium, bromine, and iodine. OPP 92-23951. $13,221.

MacAyeal, Douglas R. University of Chicago, Chicago, Illinois. Siple Coast ice-stream response to atmospheric carbon dioxide variation. OPP-9218078. $60,333.

Markgraf, Vera. University of Colorado, Boulder, Colorado. Conference on Late Quaternary paleoclimates in the Americas: Dynamics of past climate change and its forcing along a transect from pole to pole; Panama, 10–12 September 1993. ATM 93-02551. $10,000 ($45,783).

Powell, Ross D. Northern Illinois University, De Kalb, Illinois. Evaluation of processes at polar glacier grounding-lines to constrain glaciological and oceanographic models. OPP 92-19048. $102,228.

Raymond, Charles F. University of Washington, Seattle, Washington. Geophysical surveys and ice-flow modeling to support ice coring for paleoclimate in the Antarctic Peninsula. OPP 87-16243. $5,000.

Saltzman, Eric S. University of Miami, Miami, Florida. Antarctic ice core records of oceanic emissions: Sulfur, bromine, iodine, and selenium. OPP 92-22178. $125,827.

Waddington, Edwin D. University of Washington, Seattle, Washington. Reconstruction of paleotemperatures from precision borehole temperature logging: A Transantarctic Mountains transect from Taylor Dome to the Ross Sea. OPP 92-21261. $88,274.

Support services

Ferrell, William M. Department of Defense, Washington, DC. Logistic support of the U.S. program in Antarctica. OPP 76-10886. $20,000,000.

Sullivan, Cornelius W. University of Southern California, Los Angeles, California. Intergovernmental Personnel Act assignment. OPP 93-12712. $74,441 ($148,883).

Errata

Three errors appeared in the June 1993 issue of the *Antarctic Journal*. The author of "Campout, 26 July 1992, at the Earth's South Pole" was incorrectly listed as Steven Warren rather than Stephen Warren. In "Four ARS volumes available from the American Geophysical Union," the editors should have been James P. Kennett (rather than "Kennet") and Detlef A. Warnke. Finally, the U.S. Antarctic Program installed the first of 6, not 600, automated geophysical observatories during the 1992–1993 austral summer.

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Antarctic Journal of the United States—A new look

The September issue of the *Antarctic Journal* traditionally inaugurates the new austral summer season of research. With this issue, we also have given the journal a new look. Over its 27-year history, the journal has appeared in various forms, but this is the first major change in design. Although the content and frequency of the journal will remain the same, NSF hopes that readers will find the new format more appealing visually.

Two years ago, a survey of *Antarctic Journal* readers indicated that, in addition to reports about research, policy, and other related topics, people were interested in visual presentations of U.S. antarctic activities. This new design will provide a better format to display this aspect of the program.

Readers are encouraged not only to comment on the new design but also to let NSF know what types of information they would like to see in the *Antarctic Journal*. The editor also welcomes contributions from readers; however, all manuscripts will be reviewed to ensure that the content and style are appropriate for the *Antarctic Journal* audience. Contributions, comments, or other information should be sent to Editor, *Antarctic Journal of the United States*, Office of Polar Programs, National Science Foundation, 4201 Wilson Boulevard, Arlington, VA 22230.