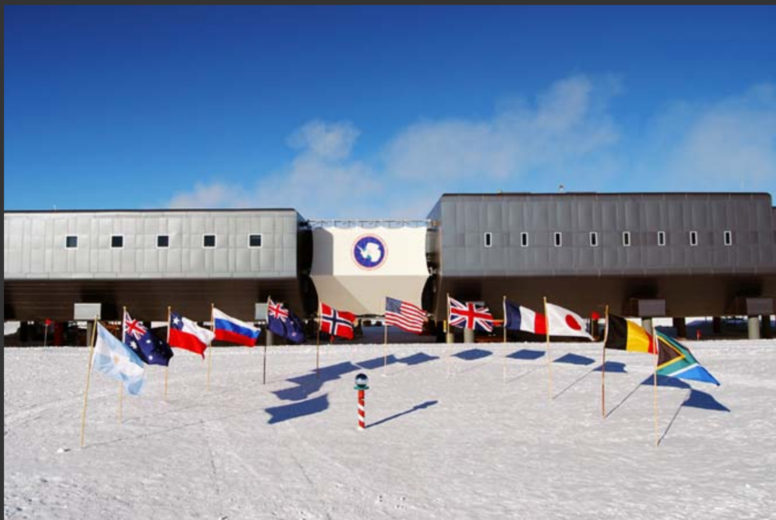
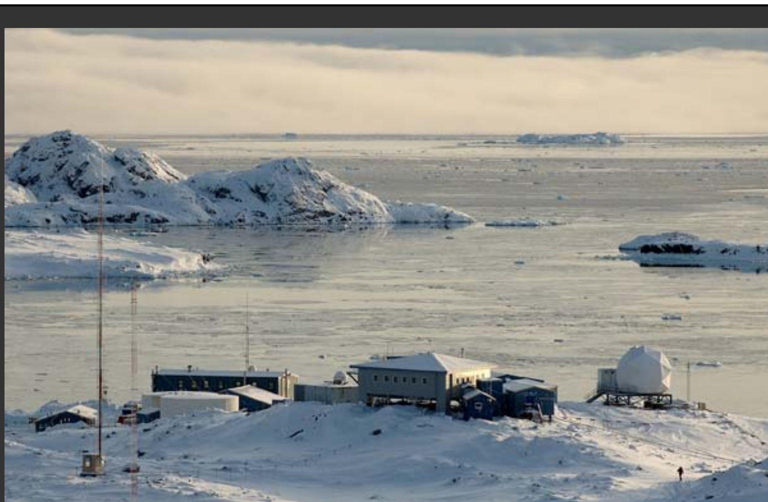
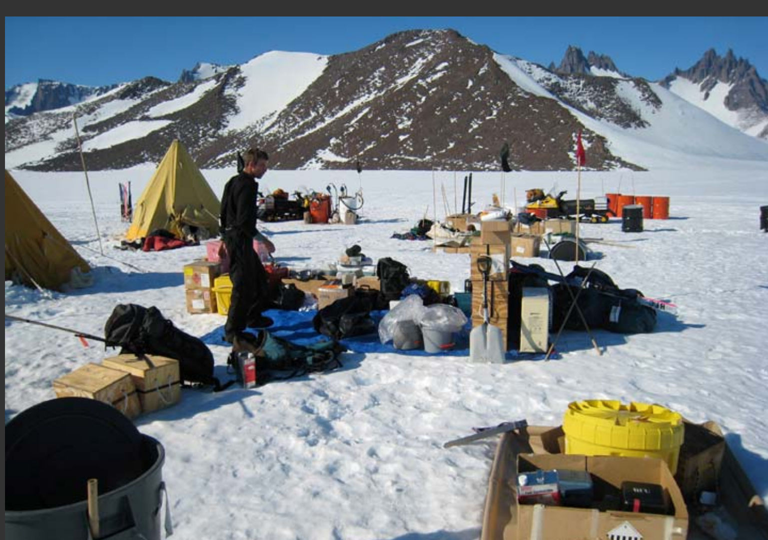
November 2008 Edition



Flags fly at the ceremonial South Pole in front of the new station by Dwight Bohnet



Palmer Station at sunrise by Glenn Grant



A geological field camp at the Dufek Massif, Pensacola Mountains by Bill Meurer

United States Antarctic Program

2008-2009 Season

Summary and Background

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1. Why perform scientific research in the Antarctic?

a. **Largest ocean current.** The Antarctic Circumpolar Current transports 130 million cubic meters of water per second towards the east, making it the mightiest of the ocean's currents. It influences formation of cold, dense, and nutrient-rich bottom water that extends throughout much of the world ocean and is a key to understanding change in the world's ocean circulation and its influence on global climate.[1] Recent research has shown that understanding the carbon cycle in the Southern Ocean is critically important to understanding the global carbon cycle.

b. **Marine ecosystem.** Research on the marine ecosystem around Antarctica is providing an understanding of the strong coupling in the Southern Ocean between climate processes and ecosystem dynamics[2] and helps to understand levels at which harvesting can take place without damaging the ecosystem.

c. **Sea ice.** The annual eightfold growth and decay of sea ice around Antarctica has been termed the greatest seasonal event on Earth.[3] It affects regional climate and the global heat budget. Particularly near the edges, it nurtures some of the world's most productive ecosystems.[4]

d. **Ozone hole.** One of the best examples of basic research about Earth's environment that led to important public policy decisions is the story surrounding the Antarctic ozone hole. The discovery of the annual Antarctic ozone depletion, the research that uncovered the cause of the ozone depleting reactions, and the subsequent decisions about phasing out ozone depleting CFC's is a compelling illustration of the value of science to society. Starting in 1979, ozone in the stratosphere over Antarctica has been observed almost to disappear every austral spring. In the 1990's seasonal ozone depletion in the Arctic was first observed. Elsewhere, stratospheric ozone depletions are only incremental. Stratospheric ozone keeps much of the Sun's harmful ultraviolet radiation from reaching the Earth's surface and therefore, the ozone hole has received widespread attention.

   i. **Finding the cause.** Research in Antarctica, particularly at McMurdo, was key to explaining how Antarctic natural phenomena conspire with the global buildup of manmade chemicals to cause the ozone hole.[5]

   ii. **Removing the cause.** The research led to an international decision (the Montreal Protocol) to reduce production of the destructive chemicals. Annual consumption of CFCs dropped from 1,100,000 tons in 1986 to 150,000 tons in 1999. Without the protocol, consumption would have reached 3,000,000 tons by 2010.[6]

   iii. **Monitoring the recovery.** While atmospheric concentrations of the harmful manmade chemicals are in decline, it might take another 10 years of observation before we can be sure the Antarctic ozone hole is shrinking. The best estimates are that annual depletion will occur for another 50 years. Current Antarctic research continues to provide further understanding of the ozone hole.[7]

iv. **Effect on life.** The ozone hole lets abnormally high levels of the Sun's ultraviolet-B radiation penetrate to the Earth's surface and oceans. Scientists have documented how UV-B affects bacteria, phytoplankton, and the embryos of Antarctic invertebrates and fish.[8]

v. **Effect on climate.** Research indicates that the ozone hole has increased the winds around Antarctica and reduced rainfall in Australia and elsewhere.[9] Some research indicates that the annual ozone depletion allows additional heat loss from the earth resulting in the minor cooling observed in the Antarctic interior.

vi. **Awards.**

a. The 1995 **Nobel Prize** in Chemistry was awarded to three professors who explained that the ozone layer is sensitive to anthropogenic emissions.[10]

b. The 1999 **National Medal of Science** (the Nation's highest scientific honor) was awarded to Dr. Susan Solomon, who led U.S. Antarctic Program expeditions in 1986 and 1987 giving the first direct evidence that anthropogenic chlorine depletes stratospheric ozone.

c. The 2002 **National Medal of Technology** (the Nation's highest honor for technological innovation) was awarded to the DuPont Company for leadership in the phase-out and replacement of chlorofluorocarbons (CFCs).[11]

e. **Polar adaptations of biota.** Antarctica's cold, desert conditions, and annual light cycles have led to molecular, biochemical, and physiological adaptations that enable biota to survive, reproduce, and indeed thrive under environmental extremes not experienced elsewhere. Studies provide a basic understanding of these unique adaptations and help us understand how changes in populations may be linked to changing climate.[12]

f. **Atmospheric background levels.** Antarctica is the planet's farthest region from human population centers and is ideal for recording the world's background levels of atmospheric constituents. Measurements since 1956 at the geographic South Pole have documented changes in worldwide levels of greenhouse gases such as carbon dioxide and methane. Measurements in the data-sparse Southern Hemisphere are important to understanding and predicting global levels of these gases and their impact on (or forerunner to) climate change.[13]

g. **Weather and climate.** The unbroken collection of weather data from manned and unmanned stations in Antarctica, now exceeding 40 years for some locations, provides a data base and real-time information from which to make operational forecasts, study the dynamics of the Antarctic atmosphere, and chart the progress of human-induced global warming.[14]

h. **Ice sheets and ice shelves.** Antarctica's ice sheets contain 90 percent of the world's ice and 70 percent of the world's fresh water. Melted, it would raise sea level 65 meters (200 feet).

i. **Global process.** Antarctica's ice—the world's largest area of cold (the Arctic is 35^{o}F warmer)—affects and responds to world climate change. Just 20,000 years ago, the ice sheet was far larger, and correspondingly, sea level was 11 meters (36 feet) lower, as the water was locked up in Antarctic ice.[15]

ii. **Climate history.** The ice, deposited as snow over millions of years, traps past atmospheric constituents that reveal climate history with a precision not equaled by other proxies such as ocean sediments and tree rings. The world's deepest ice core (3,650 meters) and another core containing the world's oldest ice (possibly 1 million years old) were both drilled in Antarctica.[16]

iii. **West Antarctic Ice Sheet**. The West Antarctic Ice Sheet if melted would raise sea level 5 meters. It is less stable than the East Antarctic Ice Sheet because its base is below sea level. Its low-probability/high-impact collapse has stimulated vigorous research over the last 30 years, revealing that it has largely or completely disappeared in the past after it formed but at an unknown rate. Portions of it are changing rapidly now, while averages over the whole ice sheet show little change. Some models project stability, while others suggest the possibility of rapid change.[17]

iv. **Ice shelf dynamics.** Ice shelves—extensions of continental ice sheets that are afloat on the ocean—can control the rate at which their parent ice sheets or glaciers move into the sea and can respond more quickly than ice sheets to environmental change. The Larsen Ice Shelf on the east coast of the Antarctic Peninsula lost massive sections in 1995 and 2002, possibly in response to atmospheric and oceanic warming over the last several decades. Some scientists call it a model for what could happen to larger ice shelves farther south.[18]

v. **Subglacial lakes.** More than 70 lakes lie beneath the ice sheet, most of them several kilometers long. One, Vostok Subglacial Lake, is an order of magnitude larger and represents the closest analog to both Europa (a moon of Jupiter) and a Neoproterozoic ("Snowball Earth") subglacial environment. Lake Vostok is likely oligotrophic—an environment with low nutrient levels and low standing stocks of organisms. Life there may depend on alternative energy sources and survival strategies.[19]

vi. **Monitoring Ice Mass Change and Sea Level Rise.** The Gravity Recovery and Climate Experiment (GRACE) satellite mission offers important observations about changes in mass in the Antarctic region. This mass change is predominantly due to two interwoven processes; 1) changes in ice mass and 2) the response of the lithosphere beneath the ice sheet to change in ice loading. However, GRACE observations alone cannot separate these processes. Consequently, the ground observations of crustal response to changes in ice loading that will be provided by the Polar Earth Observing Network (PoleNet) are essential to fully understanding how total ice mass is changing.

i. **Polar landmass.** Almost 10 percent of the Earth's continental crust resides in Antarctica. The continent is old and stable and has been in a near-polar position for over 100 million years. It thus contains unique high latitude environmental records of a time when Earth changed from greenhouse to icehouse conditions. The landmass is different from the other continents in that Antarctica's crustal structure—or its underlying mantle—has allowed the continent to remain essentially fixed on Earth's surface for a long time.

j. **Astronomy by high-altitude balloons.** Antarctica's summer weather provides a stable ride for instruments suspended from a balloon, which floats around Antarctica at a steady height above most of the atmosphere, providing a relatively inexpensive way to get scientific experiments into near-space. [20]

    i. The 2006 Balzan Prize for Astrophysics (one of four 1-million-Swiss-Franks awards made annually with the stipulation that half of each award must be used to support research of young investigators) was awarded to Dr. Andrew Lange of CalTech and his co-investigator Dr. Paolo de Bernardis of Italy in recognition of their contributions to cosmology, in particular the BOOMERANG Antarctic Long Duration Balloon experiment that produced the first images of structure in the Cosmic Microwave Background.[21]

k. **Astrophysics and astronomy from the surface**. The cold, clean, dry atmosphere over the South Pole provides viewing conditions that in some wavelengths are equal to those in space. Amundsen-Scott South Pole Station has become a major astronomy and astrophysics center.[22]

    i. **Cosmic Microwave Background Radiation (CMBR)** has been studied at the South Pole with unprecedented accuracy. Predicted in 1980s, the CMBR polarization was revealed for the first time in experimental data obtained by the University of Chicago Degree Angular Scale Interferometer (DASI)[23] in 2002. Current studies are trying to detect the B-mode polarization with the Caltech small telescope BICEP[24]. The 10-m South Pole Telescope[25] received its first light in February 2007, and now focuses on determining the nature of dark energy and dark matter and tests cosmological models aimed at explaining the origin of the Universe.

ii. **Neutrino detection.** The ice sheet beneath the South Pole is 2,900 meters deep and is homogeneous and clear. Investigators buried downward-looking detectors to observe light produced by neutrinos (ultra-high-energy particles created by cataclysmic collisions in deep space) when they on rare occasions collide with ice molecules after they pass through the Earth. The data help in descriptions of galactic centers, dark matter, and supernovae. The observatory became the first in the world to detect neutrinos in March 2001.[26]

l. **Meteorites.** Meteorites offer important information about the origin of our solar system and Antarctica is the principal source of meteorites for science. Since 1969, teams from the United States, Japan, and Europe have collected more than 30,000 meteorite specimens from the surface of the ice sheet and represent many meteorite classes (including some from the Moon and Mars), extending our knowledge of the solar system. Antarctica has yielded four-fifths of the meteorites known to science.[27] Martian and lunar meteorites provide information about processes that helped form the crust of these bodies. The large numbers of meteorites available from the Antarctic collections have allowed unprecedented discoveries because more material has been available for destructive analysis. For example, common chondrites have yielded diamonds and other highly refractory grains that are remnants of the dust clouds that coalesced to form our solar system.

m. **Mount Erebus — one of Earth's few long-lived lava lakes.** The world's southern-most active volcano, Mount Erebus is one of the few volcanoes in the world with a long-lived (decades or more) convecting lava lake. Although the volcano was discovered by James Ross in 1841, scientists still know relatively little about its geology because of extensive snow and ice cover, its remoteness, the extreme environment, and the short field season for study.[28]

2. Season Project Highlights

The table shows this year's number of U.S. Antarctic Program research projects and related activities in Antarctica and the Southern Ocean.[29] Projects range in size from one person to tens of people, and time in the Antarctic ranges from a few days to years. Some of these 118 science and technical projects are active at more than one location. A few are described below.

Program	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
McMurdo and camps	10	24	21	15	5	0	4	13	3
South Pole	12	0	3	3	4	0	1	2	1
Palmer	2	8	2	2	4	0	3	1	2
Ships	0	22	3	0	16	7	0	0	0
Support by non-USAP resources	0	6	2	2	1	2	0	0	0

Programs

1. Aeronomy, astrophysics
2. Organisms, ecosystems
3. Earth Sciences
4. Glaciology
5. Ocean and Atmospheric Sciences
6. Integrated System Science
7. Artists, writers
8. Technical Projects
9. IPY Education and Outreach

a. **10-meter telescope**. Construction of the 10-meter telescope, or South Pole Telescope (SPT), was completed as planned with the first light achieved in February 2007. The SPT Shield will be erected in the austral summer of FY10 or FY11.[30] The first winter of observations has proven the operational capabilities of the telescope and first observations of early galaxy clusters with the S-Z effect were achieved. The SPT will investigate properties of the dark energy that pervades the universe and accelerates its expansion, to search for the signature of primordial gravitational waves in the Cosmic Microwave Background Radiation, and to test cosmological models aimed at explaining the origin of the Universe.

b. **IceCube**. Work continues on the world's largest neutrino detector, which—after 6 years of work—will occupy a cubic kilometer of ice beneath the South Pole Station on Antarctica, deploying 4,800 photomultiplier tubes into holes that a hot water drill will make in the ice. Neutrinos are special but hard to detect astronomical messengers that can carry information from violent cosmological events at the edge of the universe or from the hearts of black holes. Historically, astronomical work in new energy regions has invariably discovered unexpected phenomena. By peering through a new window on the universe, IceCube could open new frontiers of understanding. Deployment of 13 new detector strings in the 2006-2007 season brought the array to 22 strings, or about 30 percent of the planned volume. Science operations to begin exploitation of the data have also commenced. During the 2007-2008 austral summer, the project expects to drill and deploy detector strings in 14-18 new ice holes, as well as install a similar number of Ice-Top Stations.[31]

c. **Long-term ecological research (LTER)**. Two sites in Antarctica — the McMurdo Dry Valleys and the marine environment on the west coast of the Antarctic Peninsula— are among 26 NSF-sponsored LTER sites dedicated to understanding ecological phenomena over long temporal and large spatial scales (most of the other sites are in the continental United States).[32]

d. **Weddell seal population dynamics.** Weddell seals in McMurdo Sound have been studied since 1968—providing one of the longest intensive field investigations of long-lived mammals in the world. More than 15,000 animals have been tagged, and 145,000 re-sightings have been recorded. The project is a resource for understanding the life history and population dynamics of not only Weddell seals, but also other species of terrestrial and marine mammals. New work this season includes assessing the role of food resources in limiting the populations. [33]

e. **Adelie penguin populations and climate change.** The Adelie penguin is tied to sea ice, a key environmental variable affected by rapid climate change. Researchers will investigate the populations of Adelie penguins on Ross and Beaufort Islands, where colonies have recently expanded, relative to colonies at Cape Crozier that declined during the 1960s and 1970s. The information will be related to sea ice, as quantified by satellite images. Understanding the mechanisms behind this sensitivity will contribute greatly to predicting the effects of climate change on Antarctic marine organisms.

f. **Ocean acidification and marine ecosystems.** As global carbon dioxide levels rise, the acidity of the southern ocean will increase. Excessive acidity in the marine environment can negatively affect the metabolism of planktonic marine organisms, including the ability to form shells. Researchers will evaluate the impact of elevated carbon dioxide on calcification, metabolic physiology, and organismal performance in Antarctic pteropods, an abundant, butterfly-like snail that lives in the southern ocean waters. They will begin to evaluate how impacts on the pteropod population affect the function of the larger marine ecosystem.[34]

g. **Protein function in cold-adapted fish.** Antarctic fish live in an unusually cold environment where basic processes such as protein synthesis are thermodynamically challenging. Researchers are examining whether Antarctic fish have unique adaptations for making proteins and are uncovering the genetic basis for these functions. Comparative studies with temperate fish will help to illuminate the evolutionary pathways of cold-adaptation and life in extreme environments.[35]

h. **Influence of light, iron and carbon dioxide on Ross Sea productivity and biogeochemical cycling.** The Ross Sea is a region of intense biological productivity, where phytoplankton biomass is dominated by two main taxonomic groups: diatoms and Phaeocystis. It is well known that these two phytoplankton groups have different impacts on biogeochemical cycles in the Ross Sea, but the factors that control their relative abundance are not well understood. Researchers will investigate the effects of iron, carbon dioxide, and light levels in the Ross Sea on phytoplankton community structure. These studies will contribute to a broader understanding of carbon and sulfur cycling in the Southern Ocean.[36]

i. **LARISSA (Larsen Ice Shelf System Antarctica)** is a multidisciplinary project to study the region of the spectacular Larsen Ice Shelf collapse in 2002. The project combines ice-core paleoclimate science, marine geology, glaciology, oceanography, and marine ecology to address the changing environment in the past and present with an eye to understanding what lies ahead in the rapidly warming Antarctic Peninsula region. The emplacement of high-precision GPS stations in the bedrock at locations on the western side of the Peninsula this year will set the stage for a major ship- and aircraft-based field effort next year. Data from the GPS stations will allow determination of the rates of rebound of the Earth's surface since the large glacial mass believed to have been centered on the Peninsula has retreated. This, in turn, will aid in understanding the past climate of the region in addition to reducing uncertainties in GRACE satellite gravity-based measurements of current ice loss from the region that contributes to sea-level rise. This element of the LARISSA project is synergistic with the international POLENET project.[37]

j. **Seismograph.** The world's quietest location for an earthquake detector is 8 kilometers from the South Pole, 300 meters beneath the ice sheet surface. Completed in 2002, the station is detecting vibrations four times smaller than those recorded previously. Other seismographs have been in place since 1957, and long-term, high-latitude data have helped to prove that the Earth's solid inner core spins faster than the rest of the planet. Also, Antarctica is the continent with the fewest earthquakes, so the new station will record small regional earthquakes, leading to new insights into the Antarctic Plate.[38]

k. **West Antarctic Ice Sheet** (**WAIS) Divide.** This project, a collaboration among several research teams, will collect a 3,400-meter-deep ice core in West Antarctica. The main objectives are to develop the most detailed record of greenhouse gases possible for the last 100,000 years; to determine if the climate changes during the last 100,000 years were initiated by changes in the Northern or Southern Hemisphere; investigate the past and future stability of the West Antarctic Ice Sheet; and to investigate the biology of deep ice. This is the second season of deep drilling with the DISC Drill. The project will drill 24 hours per day, 6 days per week. The project team will resume drilling 580 meters and must get through all the brittle ice by the end of the season. This requires reaching a depth of at least 1,400 meters. All ice from the brittle ice zone (580 meters to about 1,400 meters) will be stored in the arch's core storage basement over the winter at WSD. This will allow it to relax before retrograde during the 2009-2010 austral summer. [39]

l. **U.S.-Norway Scientific Traverse.** In the second year of this 2-year International Polar Year project, U.S. and Norwegian investigators will make an overland traverse to the Norwegian Troll Station from the U.S. Amundsen-Scott South Pole Station. Scientists will investigate climate variability in Queen Maude Land on time scales of years to centuries; establish spatial and temporal impact of atmospheric and oceanic variability on the chemical composition of firn and ice in this region; and revisit areas and sites first explored during 1960s-era traverses to look for changes and establish benchmark data sets. This project is a genuine collaboration between nations; the scientists involved have complementary expertise, and the logistics relies on assets unique to each nation. It is truly an endeavor that neither nation could accomplish alone.[40]

m. **The Center for Remote Sensing of Ice Sheets (CReSIS)** is a multi-year program designed to develop special sensors and research platforms for investigating ice thickness and to use these sensors and platforms to produce ice-thickness data. Researchers will survey along and across the Thwaites Glacier flow in three regions of interest – the transition from interior ice-sheet flow to rapid basal sliding; one or two locations in the main body of the glacier; and at the grounding line of the glacier. They also will conduct high-resolution, three-dimensional surveys above the transition and within the main body of the glacier. These surveys will be repeated within a season and, if possible, repeated after 1 year to monitor changes in bed properties. Researchers will also study the englacial, bed, and subglacial properties at the WAIS ice divide using active-source seismic techniques.[41]

n. **Old buried ice**. Ice has covered Antarctica for 34 million years, but the ice is not that old. Most of it arrives as snow and leaves as icebergs within a few hundred thousand years. Buried in the McMurdo Dry Valleys is a rare ice that offers an archive of atmosphere and climate extending back millions of years. These records are important to understanding climate in a warming world. This season sees the testing of new drilling system to core the ice. [42]

o. **AGAP (Antarctica's Gamburtsev Province).** This project explores the Gamburtsev Subglacial Mountains, the world's last unknown mountain range. Buried beneath miles-thick East Antarctic Ice Sheet, the mountains will be mapped and characterized with aerogeophysical and seismic methods. The project's goal is to understand how the mountains formed and their relationship to development of the ice sheet. The project is led by the United

States and involves scientists and logistics support from the United Kingdom, Australia, Germany, China, and Japan.[43]

p. **PoleNet (Polar Observing Network)**. This project measures current motion of the antarctic plate in response to tectonic forces and ice sheet loading. The project will ultimately lead to more precise measurement of the changes in the mass of the antarctic ice sheet in response to global warming. The project is led by the United States and involves scientists and logistics support from 20 other countries including New Zealand, the United Kingdom, Italy, China, and Germany.[44]

q. **Infrared measurement of the atmosphere.** Winter measurements of atmospheric chemistry are providing data for predicting ozone depletion and climate change. Since most satellites do not sample polar regions in winter, these ground-based measurements are expected to make important contributions.[45]

r. **Surface carbon dioxide in the Drake Passage.** The Southern Ocean is an important part of the global carbon budget, and the Drake Passage is the narrowest place through which the Antarctic Circumpolar Current travels. This chokepoint is an efficient site to measure the latitudinal gradients of gas exchange, and the research icebreaker *Laurence M. Gould* will support a project to measure dissolved and total CO_2, providing data that, with satellite images, will enable estimates of the net production and export of carbon by oceanic biota.[46]

s. **Antarctic Artists and Writers Program.** Eight artists and writers will deploy to Antarctica this season between November and February. Four projects will based in the McMurdo area, one will travel to South Pole Station, and three will work in the Antarctic Peninsula at Palmer Station.[47]

t. **Ice Coring Drilling Services.** This project, one of the technical services in support of Antarctic science, provides ice core drilling to the U.S. Antarctic Program and NSF's Arctic Research Program.[48]

3. Construction Highlights

a. **McMurdo Power and Water Plant Upgrade.** The current McMurdo Power Plant was completed and brought on line in 1982 with equipment that was specified in the 1970's design of the new facility. The facility is presently the only centralized power generation plant for McMurdo Station with emergency power provided by distributed units. The distributed units are not capable of providing power to all facilities. Therefore, any significant failure in the present power plant could require shutting down a portion of the station.

   The plant upgrades will add redundancy to the power and the water systems by placing both power generation and water production in each of the water and the power plants, eliminating the single point of failure scenario for both systems without increasing the footprint on the station. The use of more efficient engines and the addition of heat recovery from both the engine jacket and exhaust gases will decrease the fuel required to operate the station.

   Phase II of Power Plant construction began in the austral summer of FY08 with final acceptance scheduled for January 2010.

b. **McMurdo Fuel Tanks Upgrade.** This project will add four 2-million gallon fuel storage tanks, one 2-million gallon redundant tank and associated distribution systems at McMurdo. Currently, a fuel tanker delivers petroleum products to McMurdo station every year. The additional storage capacity provides risk mitigation should there be circumstances that delay or prevent a scheduled tanker. Installation of additional fuel tanks at McMurdo station will also produce sufficient storage capacity to potentially skip delivery of fuel every fourth year, thus saving annualized shipping costs of approximately $4.5 M. The project includes the construction of a pump house to transfer fuel from the redundant tank back to the existing and proposed storage tanks, which will replace the existing AN8/JP5 pump facility (Building 150).

c. **South Pole Station Modernization Project.** Major construction and renovation have replaced most of the 30-year-old South Pole Station's central facilities, which exceeded their design life and could not meet projected science demands. Construction to date has included a new fuel storage facility, a new garage and shop, a new electric power plant, the kitchen and dining room, living facilities, station services, medical facilities, science labs, emergency power plant, store/post office, food-growth chamber, and computer lab. The 2005-2006 austral summer represented a major project milestone with conditional occupancy and transition of all related station operations into the new Elevated Station. In addition, the station's old communication center was relocated from the Dome to the Elevated Station.

   Construction of the Logistics Facility is scheduled to be completed and the facility will be occupied in FY09. The new station was formally dedicated in January 2008.

d. **Palmer Station Improvements.** A new 1,567 square foot science research building was constructed in FY06 for electronic observations and the installation of atmospheric monitoring equipment. Design for replacement of the station's pier will begin in FY07.

e. **National Polar-orbiting Operational Environmental Satellite System (NPOESS) Site Survey, 10Mb/s Communications.** The first field component of the NSF-NPOESS collaboration to install NPOESS satellite weather data receptor earth stations will be initiated in the 2007-2008 austral summer at McMurdo Station. This first phase consists of an upgrade to McMurdo broadband satellite communications from 3 Mb/s to 10 Mb/s. This will be accomplished by NPOESS and NSF-funded upgrades to the NSF-owned 7.2 meter satellite earth station antenna located at the Black Island Telecommunications Facility (BITF). Black Island is approximately 22 miles south of McMurdo Station and its location allows unobstructed view to the low elevations of geosynchronous communications satellites. The BITF supports the current operational satellite earth station (11 meter antenna) and a decommissioned earth station (7.2 meter antenna). The decommissioned earth station will be refurbished to operate at Ku-Band and will initiate a new 10 Mb/s service obtained via a NPOESS service contract on the OPTUS D1 satellite. Once decommissioned, the existing C-b\Band service provided by the 11-meter antenna via INTELSAT 701 will be discontinued. The 11-meter antenna will refurbished for a 60/20 Mb/s services via OPTUS D1 in future seasons to serve as the final communications solution for NSF and NPOESS receptor operations. The refurbished 7.2-meter antenna provides gap-filling service at increased data rates during the refurbishment of the 11-meter systems. The change to 10Mb/s service is scheduled for January 2008.

4. **Environmental protection; waste management**

a. Cradle-to-grave management of supply/waste stream

b. Source-point sorting and removal of all solid and hazardous waste from Antarctica, of which approximately 65 percent is recycled

c. Environmental monitoring and research

d. Comprehensive spill prevention and cleanup program (e.g., fuel lines and hoses, double-walled or bermed fuel tanks, cleanup training and equipment)

e. Permitting system in place for all scientific and other activities involving Antarctic fauna and flora

f. Educational and enforcement procedures for waste management and environmental protection

g. Sewage treatment plant at McMurdo, fully operational as of January 2003

h. Improvement of management plans for Specially Protected Areas, in cooperation with other Antarctic Treaty nations

i. Established area management and environmental protection plans for Antarctic Specially Managed Areas (ASMA):

   i. McMurdo Dry Valleys, Southern Victoria Land, ASMA No. 2 (2004): management plan written and submitted to the Antarctic Treaty by the United States and New Zealand

   ii. Amundsen-Scott South Pole Station, ASMA No. 5 (2006): management plan written and submitted to the Antarctic Treaty by the United States

   iii. Southwest Anvers Island and Palmer Basin, ASMA No. 7 (2008): management plan written and submitted to the Antarctic Treaty by the United States

j. In compliance with all applicable treaties and U.S. laws.[49]

5. **Personnel**

a. The total number of people entering and leaving Antarctica and USAP research ships over the course of the summer will be about 3,000. The U.S. Antarctic Program peak population at any given moment will be about 1,600 on land and 300 on the ships.

b. Approximately 70 percent of U.S. Antarctic Program science personnel and >90 percent of operations personnel transit New Zealand and McMurdo

c. About one-fourth of science personnel and <10 percent of operations personnel transit South America to Antarctic Peninsula locations

6. **Year-round research stations**

   a. **Palmer** (65°S 64°W), Anvers Island, west coast of Antarctic Peninsula—marine biology and other disciplines, population 10 to 44

   b. **McMurdo** (78°S 168°E), Ross Island, southwest corner of Ross Sea—all research disciplines, operational hub, logistics center, population 160 to about 1,100

   c. **Amundsen-Scott South Pole** (90° S), geographic South Pole—astronomy and astrophysics, meteorology and climate studies, population 60 to 240

7. **Summer research camps**

   a. **Siple Dome** (Siple Coast, West Antarctica). Geophysics [50]including a GPS array; automatic weather stations. [51]

   b. **Western Antarctic Ice Sheet (WAIS) Divide Camp** (West Antarctica). Glaciology, including ice-core sampling, radar surveys, and installation of a magnetometer; automatic weather stations; GPS monitoring of bedrock motion.

   c. **AGAP South Field Camp** (Gamburtsev Mountain range, East Antarctica). Seismic and aerial geophysical surveys of the Gamburtsev Mountain range; passive seismic experiment and installation of a seismometer array; and installation of autonomous, low-power magnetometer platforms for the PENGUIn project.

   d. Small field camps at Beardmore Glacier (Transantarctic Mountains) and at remote sites supported by other national antarctic programs.

   e. Numerous camps in the McMurdo Dry Valleys, on sea ice, and on Ross Island.

8. **Logistics Traverse**

   Extending prior work, two South Pole Traverses are planned from McMurdo to South Pole and back between 20 October 2008 and 8 February 2009. The traverses will move fuel and cargo between the two stations, reducing the demand on LC-130 airplanes.

9. **Ships (research and support)**

   a. RV *Nathaniel B. Palmer*, length 94 meters, icebreaker, purpose-built in 1992 for long-term charter to U.S. Antarctic Program. [48]The ship supports research throughout the Southern Ocean the year-round.

   b. RV *Laurence M. Gould*, 71 meters, ice-strengthened, purpose-built in 1997 for long-term charter to U.S. Antarctic Program (replaces RV *Polar Duke*, chartered 1984-1997). [52] Year-round research and Palmer Station support.

c. *Polar Sea*, 122 meters, U.S. Coast Guard icebreaker.[53] Annual summer channel break-in to McMurdo and some summer-season research support.

d. *Oden*, 107.8 meters, Swedish Maritime Administration with the annual summer channel break-in to McMurdo and escort of the *Tern* and the tanker.[54]

e. *American Tern*, 159 meters, Military Sealift Command chartered ice-classed cargo ship.[55] Annual cargo delivery to and waste retrograde from McMurdo.

f. Tanker, Military Sealift Command (MSC) chartered. Annual fuel delivery to McMurdo.

10. Runways (wheeled operations near McMurdo)

a. McMurdo Sound (78°S), annual sea ice, October to December

b. Pegasus (78°S), prepared glacial ice; previously not used in the warmer summer months, this runway was groomed for year-round use in 2001.

11. Skyways (ski operations only)

a. Williams Field (78°S), near McMurdo, available year-round

b. South Pole (90°S)

c. Open field (various locations)

12. Antarctic Mission and Policy

a. White House Memorandum 6646 (1982)[56]

i. United States will maintain an active and influential presence in Antarctica that supports the range of its interests under the Antarctic Treaty.

ii. National Science Foundation will budget for and manage the National program, including university and Federal research and logistics, as a single package.

iii. Departments of Defense and Transportation will provide logistics (reimbursed).

iv. NSF will use commercial support and management where cost effective and not detrimental to the National interest.

v. Other agencies may do short-term science when operations in Antarctica are coordinated with NSF.

b. Presidential Decision Directive NSC-26 (1994)

i. Protect Antarctic environment.

ii. Protect opportunities for scientific research.

iii. Maintain Antarctica as an area of international cooperation for peaceful purposes.

iv. Conserve living resources in the oceans surrounding Antarctica.[57]

c. President's National Science and Technology Council review (1996)[58]

i. Presidential Memorandum 6646 continues to be appropriate at the current funding level.

ii. U.S. Antarctic Program is cost effective in advancing American scientific and geopolitical objectives.

iii. Continue three stations with year-round presence.

d. U.S. Antarctic Program External Panel (1997)[59]

i. Program is well managed, involves high quality science, and is important to the United States.

ii. An Optimized South Pole Station should replace the existing station.

13. Overall National achievement

a. **Peace.** Antarctica has been reserved for peace as a result of international cooperation stimulated in part by a 1948 U.S. international initiative, by U.S. leadership during the 1957–1958 International Geophysical Year, and by the Antarctic Treaty signed in 1959 by 12 nations in Washington, D.C.

b. **Knowledge.** Antarctic research has enabled discoveries of fundamental societal importance that could not have been achieved without a substantial scientific and operational presence in Antarctica and the Southern Ocean. Research since the IGY has provided the basic understanding of Antarctica and its key role in global processes. Antarctica is the last continent to be explored and studied; more than 90 percent of the world's Antarctic research literature has been published in the 46 years since the IGY.

c. **Leadership.** Through its year-round presence in Antarctica and participation in international Antarctic affairs, the United States has maintained scientific and political leadership and assured U.S. participation in future uses of the region.

14. National Science Foundation[60]

a. **Mission.** The National Science Foundation is a catalyst for progress in discovery and learning. NSF provides leadership, stewardship, and funds to sustain and strengthen the Nation's science, mathematics, and engineering capabilities and education and to promote the use of those capabilities in service to society.

b. **Organization.** NSF, a U.S. Government agency established in 1950, has a staff of 1,200 and directorates or offices for mathematics and physical sciences (including chemistry and astronomy); geosciences (earth, atmosphere, ocean); biological sciences; sociological, behavioral, and economic sciences; engineering; computer sciences and information systems; education; international activities; environmental studies; crosscutting programs; and polar programs.

c. **Primary activity.** Scientists, engineers, and educators at U.S. institutions compete for support by submitting proposals that respond to NSF program areas.[1] Annually:

   i. 30,000 proposals competitively reviewed

   ii. 10,000 new awards to 2,000 institutions

d. **Budget (NSF Overall).** The National Science Foundation requests $6.02 billion for FY 2007, $439 million or 7.9 percent over the FY 2006 request of $5.58 billion.

e. **Budget (NSF Antarctic).** NSF spending in FY 2007 for the U.S. Antarctic Program was $353.61 million, of which $56.65 million was for research grants and Science & Technology Center, $166.24 million was for operations and science support, $5.79 was for Environment, Health & Safety, $67.52 million was for logistics, and $52.96 was for USCG polar icebreakers operating in the Arctic and the Antarctic. NSF funds about 97 percent of all Federally supported Antarctic research and research support. For FY 2008, NSF estimates that it spent $351.69 million, of which $69.35 million was for research grants and the Science & Technology Center, $160.84 million for operations and science support, $5.98 for Environment, Safety & Health, and $67.52-million for logistics. NSF also budgeted $57 million for operation and maintenance of the USCG polar icebreakers. For FY 2009, NSF has requested $387 million, of which $71.24 is for research grants and the Science & Technology Center, $187.50 million is for operations and science support, $6.74 is for Environment, Safety & Health, and $67.52-million is for logistics. NSF also budgeted $54 million for operation and maintenance of the USCG polar icebreakers.

   i. In FY 2007 to fund and support research during the International Polar Year, NSF requested $61.57 million of which $48.48 million was part of the Office of Polar Programs budget. In FY 2008, NSF requested $58.67 million of which $47.27 million will support IPY research and education projects supported by the Office of Polar Programs.[61]

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[1] "The Southern Ocean," by Arnold L. Gordon, *Current* 15(3): 4-6, 1999. The bountiful recent literature on the topic includes "What drove past teleconnections?" by Frank Sirocko, p. 1336-1337, *Science*, 5 September 2003.

[2] Hhttp://www.ccpo.odu.edu/Research/globec_menu.html

[3] The area of sea ice around Antarctica varies between 1 and 8 million square miles annually. See images 4 and 5 in Hhttp://www.nsf.gov/od/opp/antarct/images/start.jspH.

[4] Hhttp://www.antcrc.utas.edu.au/aspect/

[5] "Overview of the polar ozone issue," by Solomon, S.; Schoeberl, M.R. (ed), *Geophysical Research Letters*, 15(8), p.845-846 (August 1988), introduces a special issue on polar ozone.

[6] "Montreal Protocol Benefits Cited," page 395, 30 September 2003 *EOS*.

[7] Hhttp://www.cmdl.noaa.gov/ozwv/ozsondes/spo/ozhole.htmlH (historical significance of the ozone hole)

[8] Scroll down to "Ozone Hole Consequences" in Hhttp://www.theozonehole.com/

[9] "Ozone and climate change," p. 236-237, and "Simulation of recent Southern Hemisphere climate change," p. 273-275, *Science*, 10 October 2003. Hwww.sciencemag.orgH.

[10] Hhttp://www.nobel.se/chemistry/laureates/1995/

[11] Hhttp://www.technology.gov/Medal/p_Recipients.htm#2002

[12] See, for example, *The Adélie Penguin: Bellwether of Climate Change*," Columbia University Press, October 2002 Hhttp://www.columbia.edu/cu/cup/catalog/data/023112/023112306X.HTM

[13] The Climate Monitoring and Diagnostics Laboratory, National Oceanic and Atmospheric Administration, operates four baseline observatories worldwide, including the one at the South Pole in cooperation with NSF. See Hhttp://www.cmdl.noaa.gov/

[14] The automatic weather station project, University of Wisconsin, is described at Hhttp://amrc.ssec.wisc.edu/aws.html

[15] Hhttp://igloo.gsfc.nasa.gov/wais/articles/perspective.html

[16] Russian, French, and U.S. investigators drilled and analyzed the world's deepest ice core (3,650 meters). The core spans four glacial-interglacial cycles, furnishing an

unparalleled archive. “Climate and atmospheric history of the past 420,000 years from the Vostok ice core, Antarctica,” by J.R. Petit and others, *Nature* (London), 399(6735), 429-436, 1999. European coring at Dome C, East Antarctica, in 2003 reached 3,200 meters, yielding some of the world’s oldest ice, possibly 1 million years old.

[17] Hhttp://igloo.gsfc.nasa.gov/wais/

[18] “Warmer ocean could threaten Antarctic ice shelves” (p. 759) and “Larsen Ice Shelf has progressively thinned” (p. 856-859), *Science*, 31 October 2003, Hwww.sciencemag.orgH. See also Hhttp://nsidc.org/sotc/iceshelves.htmlH.

[19] Hhttp://www.ldeo.columbia.edu/~mstuding/vostok.html

[20] A microwave telescope borne for 10½ days 120,000 feet over Antarctica provided detailed evidence that the large-scale geometry of the universe is flat (*Nature*, 27 April 2000). Following the Big Bang 12-15 billion years ago, the universe was smooth, dense, and hot. The intense heat still is detectable as a faint glow called cosmic microwave background radiation. Scientists had sought high-resolution images of the radiation since 1965, when a ground-based radio telescope discovered it. Hhttp://www.nsf.gov/od/lpa/news/press/00/pr0025.htm

[21] See Hhttp://www.balzan.com/index_en.cfm

[22] The University of Chicago (Yerkes Observatory) and 15 institutions from four nations installed telescopes at South Pole Station emphasizing infrared and submillimeter wavelengths. This large project, one of NSF's 24 Science & Technology Centers, in 2001 provided science with the strongest evidence to date for the theory of inflation, the leading model for the formation of the universe. Hhttp://www.nsf.gov/od/lpa/news/press/01/pr0138.htm

[23] Hhttp://astro.uchicago.edu/dasi

[24] Hhttp://www.astro.caltech.edu/~lgg/bicep_front.htm

[25] Hhttp://spt.uchicago.edu/

[26] Hhttp://amanda.berkeley.edu/

[27] Hhttp://geology.cwru.edu/~ansmet/

[28] Hhttp://www.ees.nmt.edu/Geop/mevo/mevo.html

[29] For each project with an NSF grant, a description including contact information and grant amount is in the Foundation’s grants database, Hhttp://www.fastlane.nsf.gov/a6/A6SrchAwdf.htmH. U.S. Antarctic Program participants also can request access to the *2006-2007 Science Planning Summary, United States Antarctic Program*, which describes all projects.

[30] Hhttp://astro.uchicago.edu/scoara/may2004workshop/TALKS/spt-carlstrom/

[31] Hhttp://www.icecube.wisc.edu

[32] LTER network: Hhttp://lternet.edu/H; McMurdo LTER: Hhttp://huey.colorado.edu/LTER/H; Palmer LTER: Hhttp://iceflo.icess.ucsb.edu:8080/ice_hp.php?

[33] Hhttp://www.homepage.montana.edu/~rgarrott/index.htm

[34] Hhttp://www.csusm.edu/Biology/bios/fabry.htm

[35] Hhttp://hofmannlab.msi.ucsb.edu/

[36] Hhttp://www.whoi.edu/sites/corsacs

[37] Hhttp://www.hamilton.edu/news/exp/LARISSA/index.htmlH

[38] Hhttp://www.iris.washington.edu/about/GSN/

[39] Hhttp://waisdivide.unh.edu/

[40] Hhttp://traverse.npolar.no/H

[41] Hhttps://www.cresis.ku.edu/

[42] Hhttp://people.bu.edu/marchant/themesBuriedIce2.htm

[43] Hhttp://www.ldeo.columbia.edu/research/marine-geology-geophysics/agap-exploring-gamburtsev-subglacial-mountains-antarctica-during-H

[44] Hhttp://www.polenet.org/H

[45] Hhttps://www.fastlane.nsf.gov/servlet/showaward?award=0230370

[46] Hhttp://www.ldeo.columbia.edu/res/pi/CO2/

[47] Hhttp://www.nsf.gov/od/opp/antarct/artist_writer/fy07awards.jsp

[48] Hhttp://www.ssec.wisc.edu/icds/

[49] The Antarctic Conservation Act, Public Law 95-541, authorizes U.S. regulations for compliance. See Hhttp://www.nsf.gov/od/opp/antarct/aca/aca.jsp

[50] Hhttp://www.geosc.psu.edu/~sak/Tides

[51] The automatic weather station project, University of Wisconsin, is described at Hhttp://amrc.ssec.wisc.edu/aws.html

[52] Hhttp://www.usap.gov/vesselScienceAndOperations/H

[53] Hhttp://www.uscg.mil/pacarea/cgcPolarSea/default.asp

[54] Hhttp://www.shipadm.org/templates/SFVXPage____1077.aspx

[55] Hhttp://www.msc.navy.mil/N00p/pressrel/press04/press31.htmH (MSC announcement); Hhttp://www.amo-union.org/Newspaper/Morgue/10-2002/Sections/News/newjobs.htmH (*American Maritime Officer* news item)

[56] For the full text, see appendix B in Hhttp://www.nsf.gov/od/opp/ant/memo_6646.jsp

[57] Hhttp://swfsc.nmfs.noaa.gov/aerd/

[58] The 67-page report *United States Antarctic Program*, April 1996, is in the NSF web site at Hhttp://www.nsf.gov/pubs/1996/nstc96rp/start.htm

[59] The 94-page report *The United States in Antarctica*, April 1997, is at Hhttp://www.nsf.gov/publications/pub_summ.jsp?ods_key=antpanel

[60] Hhttp://www.nsf.gov

[61] Hhttp://www.nsf.gov/funding/H (Browse NSF funding opportunities)