

The Geodesy and Mapping Program of the United States Geological Survey in Antarctica

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Antarctica is one and one half times the size of the continental United States and on average it is the coldest, highest and driest continent on Earth.

The U.S. Geological Survey (USGS) conducts geodesy and mapping investigations in Antarctica under the auspices of the National Science Foundation (NSF). Those activities include managing the global positioning system (GPS) base stations at McMurdo, Amundsen-Scott South Pole, and Palmer Stations; installing absolute gravity stations; establishing geodetic control; developing the Atlas of Antarctica Research; coordinating topographic and satellite image mapping; providing oversight for Antarctic geographic place names; and, managing the U.S. Antarctic Resource Center (USARC).

Geodetic field programs are required to support national and international research to define the Earth's geoid and provide the basis for spatial reliability in mapping. Several USGS projects support this objective, including the International GPS Service (IGS) continuous observing stations at McMurdo, Amundsen-Scott South Pole, and Palmer stations. The McMurdo IGS station, located at the McMurdo RADARSAT facility, operates with a late-model, dual-frequency receiver system. Similar GPS systems are deployed at the South Pole and Palmer IGS stations. Daily solutions from the continuous observations yield three-dimensional positional accuracies at the subcentimeter level. The USGS serves as the U.S.

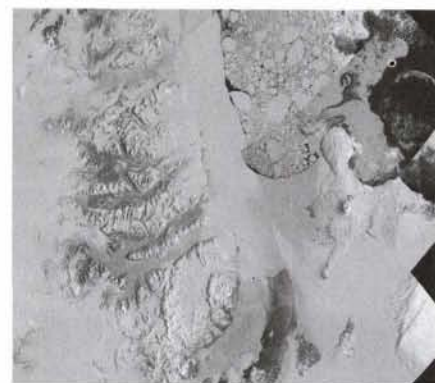
representative to the Scientific Committee on Antarctic Research (SCAR) Epoch continentwide GPS-observing campaigns in Antarctica. The campaigns connect geodetic stations in Antarctica to stations on other continents as part of a network for geodynamics investigations and for connecting the IGS

stations in Antarctica, including the USGS rock-based stations, to the global International Terrestrial Reference Frame (ITRF). During the campaigns, stations at McMurdo, South Pole, and Palmer contribute to the SCAR Epoch campaigns. Data from these stations are used to improve and extend the ITRF and monitor deformation of the solid Earth and variations in sea level, ice sheets, and the ionosphere. The SCAR Epoch campaigns are also a major component of the SCAR Geodetic Infrastructure for ANTarctica (GIANT) Program (<http://www.scar-ggi.org.au/geodesy/giant.htm>).

The USGS and Ohio State University are jointly investigating the deformation of the TransAntarctic mountains in the South Victoria Land region. Geodetic scientists and surveyors from the USGS, in cooperation with geophysicists and geologists from the Byrd Polar Institute, Ohio State University, have established specialized monuments at 30 bedrock sites to determine the relative motions of bedrock in the area. The results will help validate models for predicting tectonism and improve the accuracy of models for establishing relationships to changes in global sea level and ice sheet mass balance. Though the primary objective is monitoring vertical changes, horizontal motion will also be an important parameter.

Accuracies at the few-millimeter level are the goal for the positions of the bedrock points. These measurements will be determined by the use of late model, dual-frequency, high-quality GPS receiver/antenna systems. Combined with the "precise" ephemerides provided by the IGS, the data will be processed with the latest appropriate software. To establish a high level of confidence in the "base reference" measurements, scientists will perform four series of measurements in the long-term project, doing the fourth during the 1999-2000 field season. After "base reference" measurements are established within acceptable tolerances, and depending on the magnitude of detected and predicted motion, repeat measurements may be taken at longer intervals (2 to 4 years).

The USGS, in cooperation with the National Oceanic and Atmospheric Administration also measures absolute gravity at McMurdo Station, in the McMurdo Dry Valleys, and at the Italian Base at Terra Nova Bay. These measurements are used to establish



South Ross Sea Region. This Landsat TM image has been mosaicked, controlled, and printed at 1:250,000-scale by the U.S. Geological Survey. McMurdo Station and the Mount Erebus volcano are located on Ross Island, visible on the right side of the image. The McMurdo Dry Valleys are visible on the left side.

baseline gravity values in Antarctica. The data also support the vertical geodetic values in studies to monitor deformation, ice sheet mass changes, and variations in sea level.

In early January of each year, USGS surveyors conduct a geodetic survey to establish the position of the true South Pole (geodetic marker) at Amundsen-Scott station. The USGS installs a permanent brass marker identifying each austral summer position of the geographic South Pole. The observations have determined that the ice sheet at the South Pole moves 9.98 meters per year in a northwesterly direction.

During the past 5 years, the USGS has established a digital geospatial data and geographic information systems research project. The project uses various software and hardware to input, manipulate, and analyze Antarctic data. Databases developed by the USGS, Land Information New Zealand, and the British Antarctic Survey have been used to provide a stable backdrop for science data. Two recent results of the project are the online Atlas of Antarctic Research and georeferenced digital raster graphics (DRG) of most of the USGS-produced Antarctic maps.

Work on the Atlas of Antarctic Research, which began in December 1998, used software from the National Atlas of the United States. From that base, the Atlas has incorporated a larger range of scales of data, different projections, and a special full-resolution viewer for scanned maps. It was released for public use on October 1, 1999, and is accessible through the USARC Web site described below. The full-resolution viewer was designed to showcase the Antarctic DRG's developed through the project. The viewer also provides access to the metadata for each map and the capability to download the DRG's. Once the DRG's are indexed, the viewer will also provide a link to the USGS EROS Data Center DRG order site.

The United States and New

Zealand, under the auspices of the SCAR, have a cooperative program to produce maps of the Taylor and Wright Valleys, the Convoy Range, and the Royal Society Range in the

McMurdo Dry Valleys area. Under this cooperative program, the USGS and New Zealand establish the geodetic control, New Zealand compiles and generates digital geospatial data, and the USGS prints the maps. The 1:50,000-scale 15-minute topographic maps have 50-meter contour intervals and 25-meter supplemental contours, and include existing and new place names approved by the U.S. Board on Geographic Names (USBGN) and the New Zealand Geographic Board.

On the basis of research requirements, the USGS has produced satellite image maps at scales of 1:250,000, 1:100,000 and 1:50,000. Currently, it is developing procedures to produce image maps at the scale of 1:25,000 for the McMurdo Dry Valleys. The maps will use a combination of Landsat thematic mapper and SPOT panchromatic data. Also, the USGS produced the advanced very high resolution radiometer digital image map of Antarctica in July 1996. The 1:5,000,000-scale map contains contour data, permanent station locations, and geographic place names. An updated edition is scheduled for publication in early 2000.

The USBGN Advisory Committee on Antarctic Names is the national naming authority responsible for Antarctic names used by the United States. The USBGN publishes U.S. Antarctic Gazetteers. The latest version (1995), *Geographic Names of the Antarctic*, contains approximately 13,000 official names. Parallel with its



McMurdo Station, Antarctica. McMurdo Station is the United States' largest Antarctic research station. It is located in the South Ross Sea on Ross Island. Logistical and research support is provided by ski-equipped LC-130 Hercules and wheeled C-141 Starlifter aircraft, and ship. The summer population generally peaks around 1,000.

The Geographic South Pole is located at an elevation of 2834.9 meters. The ice sheet covering the South Pole moves 9.98 meters per year in a northwesterly direction. Temperatures of -100 degrees F are not uncommon at South Pole during the austral winter. Amundsen-Scott South Pole Station is visible in the background.



publication, the information in the new gazetteer became part of the digital database of the Geographic Names Information System of the United States. Antarctic geographic place names are available on the Internet at <http://www.usgs.gov>.

The USGS National Mapping Division manages the USARC. The Center is the depository and distribution point for Antarctic photographic and cartographic products produced by the United States. The Center has approximately 450,000 black-and-white and color aerial photographs dating from Operation Highjump (1946-47) through the 1998-99 austral field season. The Center also archives geodetic control records, satellite images, maps, charts, and publications. The maps, charts, and publications are exchanged with other nations under the provisions of the Antarctic Treaty. The Internet address for the Center is <http://usarc.usgs.gov>.

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