

# SCAR WG-GGI NATIONAL REPORT

## Report of Current Activities of US for 1998-2000

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Numerous US organizations/institutes have working programs to conduct research and operational activities in the Antarctic in the field of geodesy, photogrammetry, remote sensing, geographic information, digital geospatial databases, satellite imagery and/or digital mapping. In most cases, these programs are funded through the National Science Foundation. The US government agency responsible for the geodesy and geographic information programs in support of the Antarctic science program and operational activities is the U.S. Geological Survey.

### 1. FIELD ACTIVITIES

#### 1.1 Geodesy Program

- a) **Permanent GPS Observatories:** Permanent GPS observatories continue to be operated at US scientific stations located at McMurdo (MCM4), Palmer (PALM) and Amundsen-Scott Station, South Pole (AMUN). These stations are incorporated in the global network of the International GPS Service (IGS). Data files are transmitted daily and are usually available to the user community well within the IGS specified period of 48 hours. In 1999, data from station MCM4 was transmitted and available to user community on an hourly basis.
- b) **GPS/GLONASS Observatories:** In support of the 1998 International GLONASS Experiment (IGEX-98), a combined GPS and GLONASS receiver/antenna system was deployed for a temporary period on a station named CRAR at McMurdo Station for the period from 16 Dec. 1998 through 8 Feb. 1999. In support of the International Association of Geodesy pilot project in support of continued monitoring and research on observations of the GLONASS navigation satellite signals, the combined dual-frequency GPS/GLONASS receiver was redeployed on station CRAR at McMurdo. Observations have been continuous since about 22 December 1999 and data are transmitted daily for access by the user community.
- c) **SCAR Epoch GPS Campaigns:** Data contributed in support of the SCAR epoch GPS campaigns were limited to data available from the permanent GPS observatories located at Palmer (PALM), Amundsen-Scott Station, South Pole (AMUN), and McMurdo (MCM4).
- d) **Cape Roberts Permanent GPS/GLONASS Observatory:** In a joint US/New Zealand project, work is underway to deploy a combined GPS/GLONASS receiver/antenna system on a station located adjacent to the tide gage that has been operating nearly continuously at Cape Roberts. Cape Roberts is located about 120 km north of McMurdo station. Installation is expected to be completed during the 2000-2001 field season. Initially the power for the station (named ROBE) will be limited to combination of batteries and solar generating system. Thus, observations will be continuous only during the period when there is adequate sunlight.
- e) **TAMDEF project:** During the 1998-1999 and 1999-2000 field seasons, performed GPS observing campaigns III and IV, using late-model dual-frequency receivers and antennas, on stations of the TransAntarctic Mountain South Victoria Land DEFormation (TAMDEF) monitoring network. TAMDEF9899 and TAMDEF9900 campaigns completed the four-phase program of the joint USGS-OSU/Byrd Polar Research Center project started in November 1996 (TAMDEF9697 and TAMDEF9798). Observations included occupation of the special primary station monuments established at 30 sites in the 1996-97 and 1997-98 field seasons and performing repeat measurements of the "footprint" reference points at each site. Objectives included: (1) completing set of repeat measurements between the primary stations and adjacent "footprint" reference points, (2) completing

repeat long-baseline measurements, and (3) performing repeat observations on selected baselines with anomalies detected from the initial results of the TAMDEF9697 and TAMDEF9798 campaigns. The processing of these data and analysis of the results are being carried out by a researcher at the OSU/BPRC. Data from Antarctica-based (IGS) stations are included in the post-analysis. The results for the 4-year set of measurements is producing initial estimates for vertical and horizontal motion and will serve as a basis for comparison with measurements performed in future years to detect vertical and horizontal motion, and estimates for strain rates.

- f) **Support for VLNDEF:** Cooperative arrangements were made with the 1998-1999 and 1999-2000 Italian Antarctic Expeditions to obtain observations simultaneously between stations of the Victoria Land Network for DEformation control (VLNDEF) and stations of the TAMDEF network. This included exchange of data collected at long-term GPS base reference stations at Terra Nova Bay (station TNB1) and the TAMDEF station at Cape Roberts (ROB0).
- g) **Georeferencing aerial and satellite imagery:** This project involved establishing positions at photo-identifiable points for georeferencing aerial and satellite imagery. The field work included obtaining special 35-mm slides or prints of photo-identifiable points from a helicopter hovering over the station for use in facilitating the accurate transfer of the GPS determined coordinates, referenced to the International Terrestrial Reference Frame (ITRF), to objects on the aerial and/or satellite imagery.
- h) **South Pole IGS Station AMUN:** Performed upgrades to equipment, accessories, and software deployed in support of GPS continuous operating reference station (CORS) AMUN (established in December 1991). Annual surveys were performed to establish location for special monument to marks the location of the "mean" pole axis or the geographic South Pole on January 1, 1999 and January 1, 2000. During the 1999-2000 field seasons, a joint BPRC/OSU and USGS survey was successfully conducted to connect at the sub-centimeter level ice velocity monitoring stations to the IGS station AMUN. This included stations located about 10 km from station AMUN.
- i) **South Pole Seismic Program:** The USGS operates seismic equipment at Amundsen-Scott South Pole that is included in the Worldwide Standardized Seismograph Network and incorporated in daily analyses by the USGS National Earthquake Information Service (NEIS).
- j) **Palmer IGS Station PALM:** Performed appropriate upgrades to hardware and software to enhance reliability of operations, quality of data, and support for real-time differential GPS services at GPS CORS station PALM, established in May 1997.
- k) **VLBI observations:** There is no system installed at McMurdo, thus no activity.

## 1.2 Remote Sensing Program

- a) **GPS and GIS-Based Data Collection and Image Mapping in the Antarctic Peninsula:** High-resolution satellite images combined with the rapidly evolving global positioning system (GPS) and geographic information system (GIS) technologies has offered a quick and effective way to gather georeferenced spatial data in Antarctica. GPS- and GIS-based data collection systems are used for gathering ground truthing data in the vicinity of Palmer station, Antarctic Peninsula. For example, an application of geolocated spatial data support studies to examine changes in penguin habitats resulting in part from regional climate warming. The research application in this study yields important information on the usefulness and limits of data capture and high-resolution images for mapping in the Antarctic Peninsula.

## 2. MAPPING ACTIVITIES

**2.1 Satellite Image Maps:** The USGS has produced and printed a 1:250,000 scale image map of the South Ross Sea Region and at the 1:100,000 scale image map quadrangles of the Convoy Range, the Skelton Neve, Mount Discovery and of the Ross Island and McMurdo Sound.

The USGS has prepared Landsat Thematic Mapper (7,4,2) and Spot Panchromatic merge image maps at the 1:25,000 scale for the McMurdo Dry Valleys, the Royal Society Coast, Mason Spur-Mount Discovery, Brown Peninsula and the Islands, and four areas of Ross Island. One quadrangle has been printed and published. Denton Glacier and seven other quadrangles will be ready for publication in fall of 2000.

The new Landsat 7 satellite has systematically acquired data over Antarctica during the last field season. It includes not only the previous Thematic Mapper multi-spectral 30 meter data, but also panchromatic data with 15 meter cells. Thus, we have processed a 1:100,000 scale image map of merged Landsat multi-spectral and panchromatic data. The Darwin Glacier is to be printed later in 2000. The corresponding geo-corrected digital 7.5 meter data set provides for 1:50,000 and 1:25,000 scale hard copy output or photographic prints "on demand."

**2.2 Pending Satellite Image Mapping:** The USGS plans to print at least four of the prepared 1:25,000 scale satellite image maps and complete the processing of the four image maps at the 1:100,000 scale of the Darwin Mountains and of the six quadrangles for the Churchill Mountains to the mouth of the Nimrod Glacier. We also plan to process the six 1:100,000 scale image map quadrangle for the Prince Albert Mountains. Some of the above 1:100,000 and corresponding 1:250,000 scale image maps will be printed.

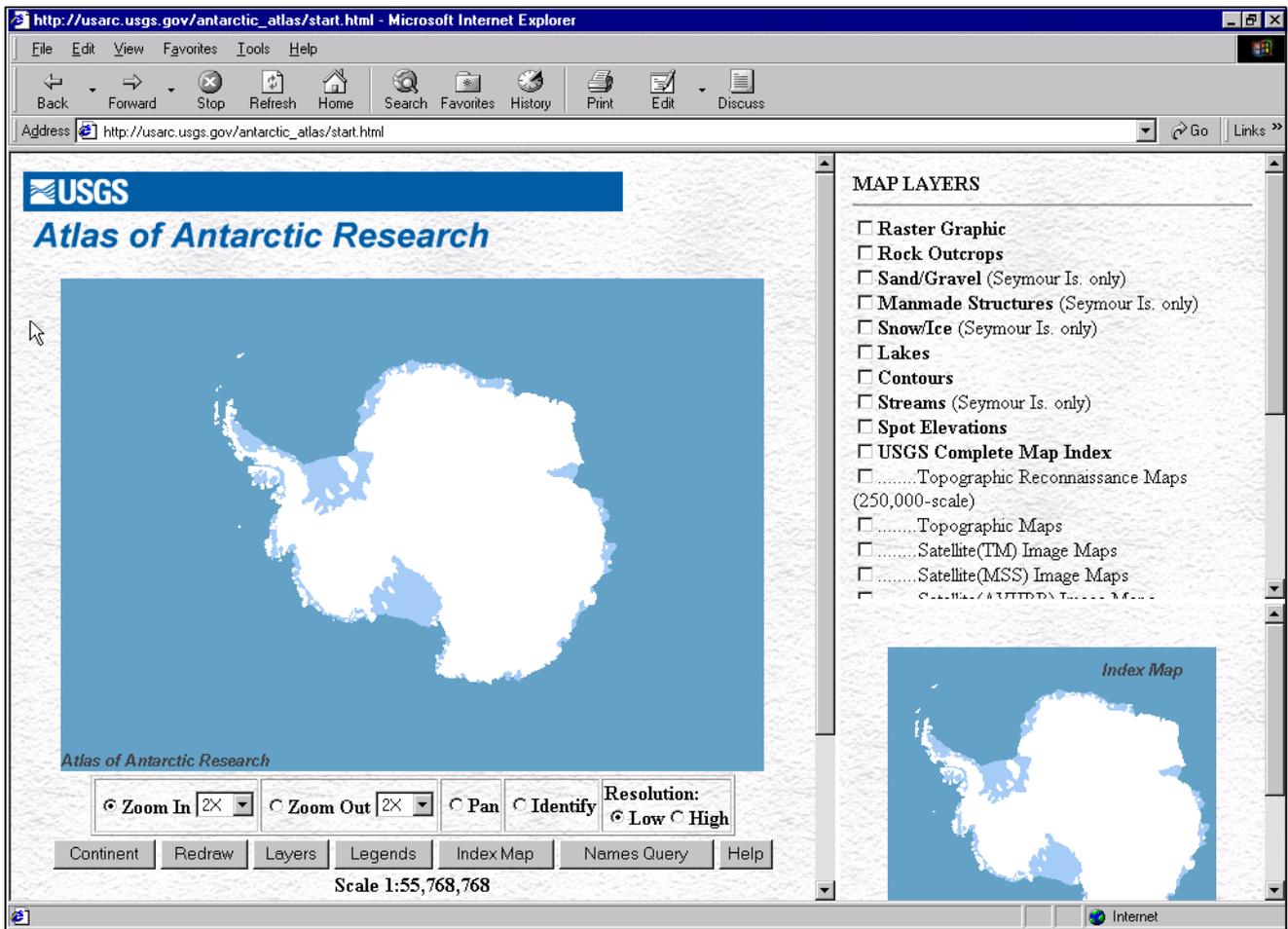
## 3. GEOGRAPHIC INFORMATION SYSTEMS/DIGITAL GEO-SPATIAL DATA

**3.1 Atlas of Antarctic Research:** The Atlas was published on-line on October 1, 1999. It was designed to provide on-line access for scientists to existing Antarctic maps and digital geospatial data (both raster and vector). As designed, it permits the display of maps of all resolutions and scales, and reference information for digital geospatial data and map indexing.

The Atlas was developed using software from the National Atlas of the United States. It has been designed to promote greater geographic awareness of the continent and the digital geo-spatial data that describe it. It provides a common base for displaying research results and data collected, as well as descriptions of ongoing and past projects. Although its primary focus is as a tool for Antarctic researchers, the Atlas is intended to serve the interests and needs of a diverse community as a reference, an information framework, an education tool, and a research aid. The U.S. Geological Survey (USGS) provides ongoing development and maintenance of the Atlas through its Antarctic Program. The U.S. National Science Foundation provides funding, logistical support and program oversight to this project.

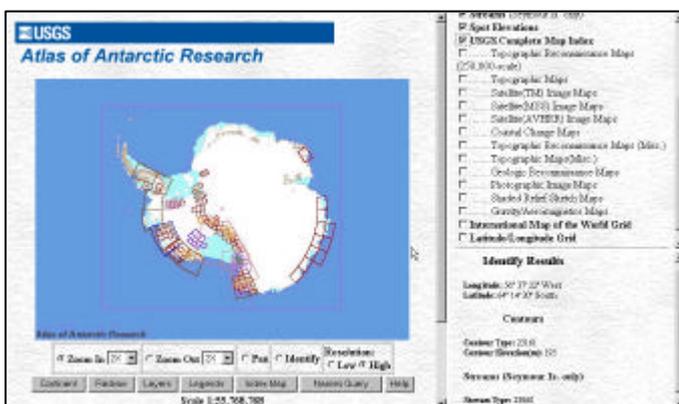
The **polar stereographic projection** was selected for display of data in the main window of the Atlas. To be added to the main map display window, all layers must be converted to that projection. Source materials for the base data in the Atlas range from scales of 1:30,000,000 (SCAR ADD) to 1:10,000 (Seymour Island) and come from several sources. As the user zooms in, the Atlas automatically replaces low-resolution layers with those of higher resolution and removes layers when the scale of display exceeds the resolution of the data. The following layers are included:

- Raster Graphic (1:250,000 - Ross Island map only)
- Rock Outcrops (1:30 million - 1:10,000)
- Sand/Gravel (Seymour Is. Only) (1:10,000)
- Manmade Structures (Seymour Is. Only) (1:10,000)
- Snow/Ice (Seymour Is. Only) (1:10,000)
- Lakes (1:30 million - 1:10,000)
- Contours (1:30 million - 1:10,000)
- Spot Elevations (1:30 million - 1:10,000)
- International Map of the World Grid
- Latitude/Longitude Grid

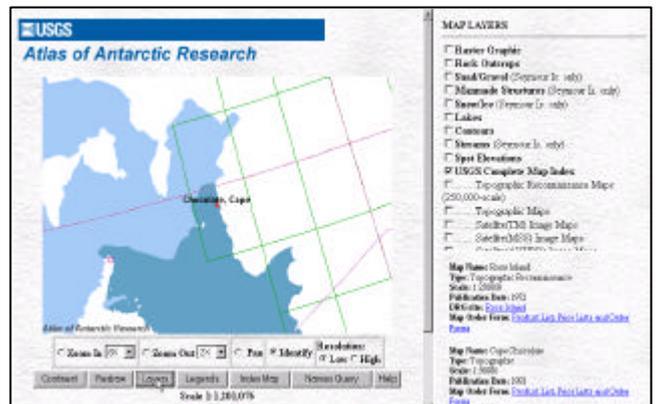


The Atlas of Antarctic Research as seen upon entry. It provides the ability to select layers or combinations of layers for display, zoom in on those layers, display information describing them, and move directly to order sites for maps and data as well as related data/information sites.

**Map index** layers have been added for the USGS-produced maps available from our Earth Science Information Centers. The map index layers of the Atlas provide information describing the maps as well as URL's to the USGS map order site. The layers also provide URL's to the DRG and geodetic control sites described below. The layers are listed below with the scale ranges of their source material.



Map Index for USGS-produced Antarctic maps.



Cape chocolate 1:50,000-scale map located

USGS Complete Map Index (contents of all layers listed below):

- Topographic Reconnaissance Maps (1:250,000-scale only)
- Topographic Maps
- Satellite (TM) Image Maps
- Satellite (MSS) Image Maps
- Coastal Change Maps
- Topographic Reconnaissance Maps (Misc.)
- Topographic Maps (Misc.)
- Geologic Reconnaissance Maps
- Photographic Image Maps
- Shaded Relief Sketch Maps
- Gravity/Aeromagnetism Maps

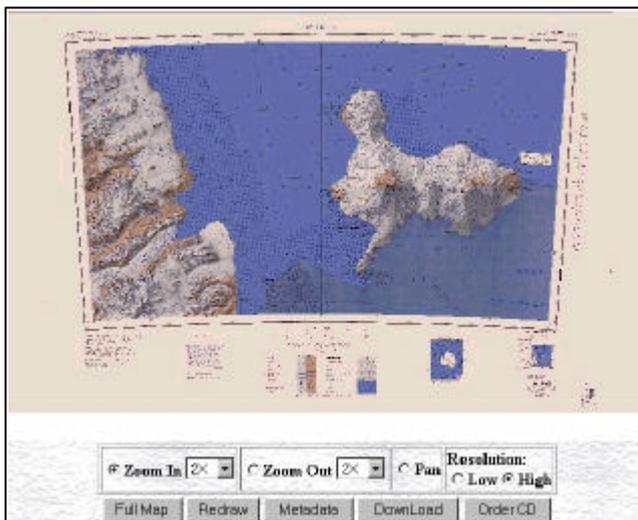
The Atlas includes a **full resolution viewer for raster data**. It currently displays the 1:250,000-scale topographic reconnaissance map Digital Raster Graphics (DRG). The viewer provides:

- Full resolution view of each DRG with Zoom and Pan capabilities
- Full metadata access
- Download of the DRG and its metadata as a compressed file
- Active link to the USGS order site for DRGs on CD-ROM

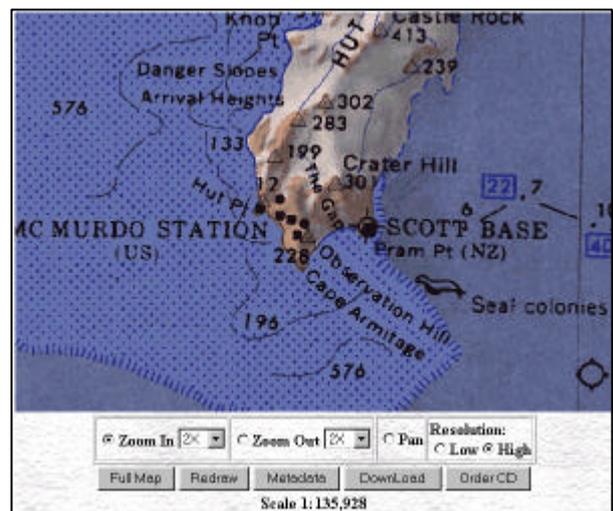
To find an individual DRG, display the Topographic Reconnaissance Map index (1:250,000-scale) layer, activate the identify button, and click in one of the boxes on the map. An active link to the DRG site will be displayed if the DRG is available. This procedure will also display an active link to a site developed by NASA that contains descriptions of geodetic control for that map if they are available. DRG links exist for all of the maps in that index, while geodetic control information is currently available for maps in the Marie Byrd Land region. As more control descriptions become available links will be added to the Atlas. When other DRGs become available, they can be similarly reached through their map index.

The **raster graphic** layer is currently under construction. It is a layer on the main map window and is designed for seamless display of all 1:250,000-scale DRGs. To view the only map currently available, search for Ross Island using the names query button. Display the feature on the map, click the layer button to redisplay the layer list, and select the Raster Graphic layer for display. Zoom in and the DRG will become visible when the scale of the display exceeds 1:500,000.

Ross Island DRG - Topographic Reconnaissance Map (1:250,000)

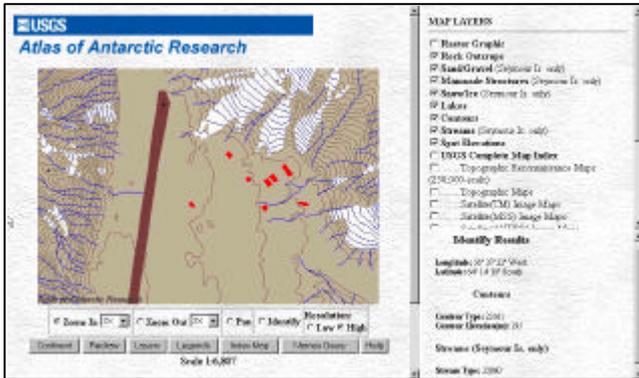


Initial display of a DRG in the full resolution window.

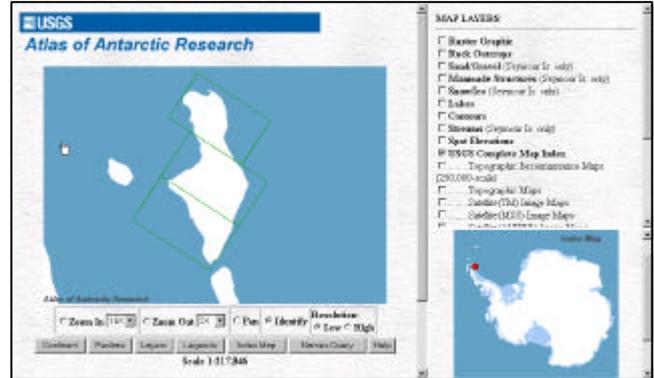


Enlarged section to show the details.

The 1:10,000-scale **Seymour Island** map is currently the highest resolution map in the Atlas. Like the raster graphic of Ross Island, it can be located using the query button. The layers from the 1:10,000-scale map will start to become visible when the display scale exceeds 1:100,000 (rock outcrops, sand/gravel, manmade features, snow/ice, lakes, and spot elevations), and the more detailed layers (contours and streams) will display when the scale exceeds 1:20,000.



Seymour Island located on continent.



Seymour Island enlarged to show data detail.

Plans for the Atlas include the addition of more raster layers, the 1:50,000-scale vector data, and the display of digital geo-referenced satellite image data from the image mapping program, and the map layers produced by the Antarctic Coastal Change Mapping Program.

**3.2 Digital Raster Graphics:** From 1998 through 1999, the USGS developed digital raster graphics for over 90 1:250,000-scale topographic reconnaissance maps. The data are in either **polar stereographic or Lambert conformal conic projection** to match the printed maps. Maps were scanned at 25.4 meters ground resolution and are available for download from the Atlas of Antarctic Research. In addition, several image and aerial photograph maps have been converted to fully geo-referenced DRGs. (See the examples in the Atlas section above.)

**3.3 Digital Topographic Data:** The USGS works jointly with New Zealand to produce 1:50,000-scale maps using digital technology. The data now include coverage of 33 maps in the McMurdo Dry Valleys. Twenty of those maps are now printed, and the next 13 are in progress. In the next two years, we plan to collect LIDAR high-resolution data for selected areas in the McMurdo area to assess its utility to the science community.

**3.4 Digital Image Data:** As the production of Satellite Image maps of Antarctica continues, the data used to produce them are being archived and will be made available for use by the science community as appropriate. Metadata will be developed and they will be added to the Atlas of Antarctic Research.

**3.5 Digital Coastal Change Data:** The international team of scientists mapping the coast of the continent is now producing digital layers of coastal information along with an image base layer. Metadata for those data sets is being generated and the resulting information will be made available through the Atlas.

#### 4. SCIENTIFIC PAPERS PUBLISHED/PRESENTED

There are numerous scientific papers and presentations on a variety of subjects related to the interests of the Working Group on Geodesy and Geographic Information prepared by researchers from academic institutions and government research groups. The USGS activities are highlighted in the paper “The Geodesy and Mapping Program of the United States Geological Survey in Antarctica,” Jerry L. Mullins, Cheryl A. Hallam, Larry D. Hothem, and Jean-Claude Thomas, *Journal of Photogrammetry Engineering and Remote Sensing*, American Society of Photogrammetry and Remote Sensing.

## 5. PLACE NAMES

Since 1993, place names have been managed by the Advisory Committee on Antarctic Names (ACAN), U.S. Board on Geographic Names. In past two years, approximately 400 place names have been approved by ACAN and submitted to the Composite Gazetteer of Antarctica.

## 6. GROUND CONTROL POINT LIBRARY

Through a NASA cooperative arrangement, the USGS continued development of "on line" access to a data base containing geodetic control and associated information.

## 7. PLANNED ACTIVITIES FOR THE NEXT TWO YEARS

### 7.1 Geodesy Program

- a) **Permanent GPS (and GLONASS) Observatories:** Support for SCAR epoch campaigns will be supported by continued availability of data collected at the permanent GPS observatories located at Palmer station (PALM), Amundsen-Scott Station, South Pole (AMUN), McMurdo (MCM4), and from the remote GPS/GLONASS observatory at Cape Roberts (ROBE). Additionally, in cooperation with JPL/NASA researchers, data collected at the remote GPS stations operating in the South Victoria Land region of the Transantarctic Mountains (stations COAT and MTCX) and the three stations located in eastern Marie Byrd Land, will be provided.
- b) **GPS Observing Campaigns for Monitoring Deformation:** During next 2 years, reoccupy selected stations of the TAMDEF network. This includes cooperation with the Italian Scientific Expedition to arrange for simultaneous observations in support of the VLNDEF project.
- c) **Absolute Gravity Measurements:** During the 2001-2002 field season and using the new Micro-g model A-10 meter, reoccupy absolute gravity stations at McMurdo, Terra Nova Bay, Cape Roberts and Mt. Coates. The observing plans include reoccupation of stations at McMurdo and Terra Nova Bay with the Micro-g model FG5 meter which were initially occupied with the FG5 meter during the 1995-6 and 1997-8 field seasons. A report on summary of results for the 95-6 and 97-8 campaigns is in preparation and will be presented at the Geodesy, Gravity and Geodynamics Symposium scheduled for early August 2000, in Banff, Canada.
- d) **Position and Orientation of airborne camera and laser scanning sensors:** Plans are underway for pilot projects to demonstrate the application of commercially available integrated GPS and inertial system for high accuracy determination of position and orientation of airborne sensors instruments such as film-based or digital cameras, and laser scanning instruments. The pilot projects are planned for the 2000-2001 and 2001-2002 field seasons.
- e) **Cape Roberts Collocated Geodetic Observatories:** Perform high accuracy geodetic connections between stations referenced to the tide gage measurements, absolute gravity observations, and the GPS/GLONASS observatory.
- e) **VLBI observations:** There is presently no facility available at McMurdo station and none is planned before July 2002.

### 7.2 Remote Sensing

- a) **Coastal-Change and Glaciological Mapping program:** continue work to publish 24 maps at 1:1,000,000 covering the coast of Antarctica. The objective of the project is to: 1) determine the Antarctic coastline change that has occurred between the mid-1970's and the late 1980s/early 1990s using Landsat and other imagery, 2) identify accurately the glaciological characteristics of the Antarctic coastline, 3) determine ice surface velocities of glaciers at the coastline. 4) compile a comprehensive inventory of the glaciers on remotely sensed data, and 5) publish the results as appropriate, including the 24 maps.

b) **Landsat/SPOT Satellite Image Map:** Work continues on producing a 1:25,000 Landsat/SPOT image maps for selected regions in the North and South Victoria Land regions of the Transantarctic Mountains. The maps will be published with the current geographic names available for the area. US and New Zealand will cooperative program to acquire ground control points used to georeference the imagery and link to the ITRF.

### 7.3 Topographic Mapping

We plan to continue our cooperative 1:50,000 scale topographic mapping program with Land Information New Zealand (LINZ) in the McMurdo region of the Transantarctic Mountains. This includes a joint project in 2000 for map compilation of Ross Island.

### 7.4 Geographic Information Activities

a) **U.S. Antarctic Resource Center (ARC):** The USGS/NMD manages the U.S. Antarctic Resource Center. The Center serves as the official depository and distribution point for all Antarctic photographic and cartographic products produced by the United States. The center has on file approximately 450,000 black-and-white and color aerial photographs of the Antarctic dating as early as the Operation Highjump (1946-47) and as recent as 1989. The center also houses geodetic control records, satellite imagery, maps, charts, and publications, exchanged under the provisions of the Antarctic Treaty between Treaty Nations.

b) **Atlas of Antarctic Research:** Work will continue to improve the Atlas, published on-line on October 1, 1999, that is designed to provide on-line access for scientists to existing Antarctic maps and digital geospatial data (both raster and vector), including display of maps of all resolutions and scales, and reference information for digital geospatial data and map indexing.