

GEOSCIENCES

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\$687,920,000

The FY 2004 Budget Request for the Geosciences Activity (GEO) is \$687.92 million, a decrease of \$3.15 million, or 0.5 percent, below the FY 2003 Request of \$691.07 million.

GEO Funding
(Dollars in Millions)

	FY 2002	FY 2003	FY 2004	Change	
	Actual	Request	Request	Amount	Percent
Atmospheric Sciences	202.15	218.92	229.92	11.00	5.0%
Earth Sciences	126.27	153.14	144.26	-8.88	-5.8%
Ocean Sciences	281.12	319.01	313.74	-5.27	-1.7%
Total, GEO ¹	\$609.55	\$691.07	\$687.92	-\$3.15	-0.5%

Totals may not add due to rounding

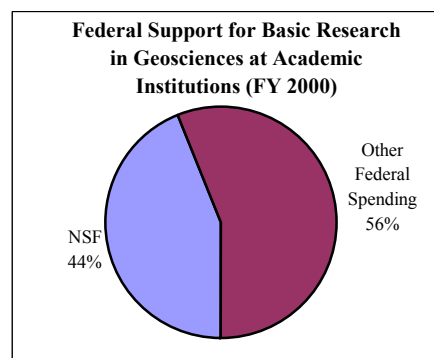
¹ FY 2003 funding includes \$74.0 million in transferred programs not re-proposed in FY 2004. Excluding the transfers, GEO would increase by \$70.85 million (11.5%).

The Geosciences Activity (GEO) supports the research, infrastructure, and education in the atmospheric, earth, and ocean sciences needed to advance our understanding of the integrated Earth system. Breakthroughs in observing, modeling, and understanding complex Earth systems are coming just at the time when society is in critical need of sound scientific advice on how to mitigate or adapt to changes in the habitability of the planet. The geosciences stand poised to make tremendous contributions to improve the quality of life by providing useful information to decision makers about the key planetary processes, their complex interactions, and where possible, their future implications.

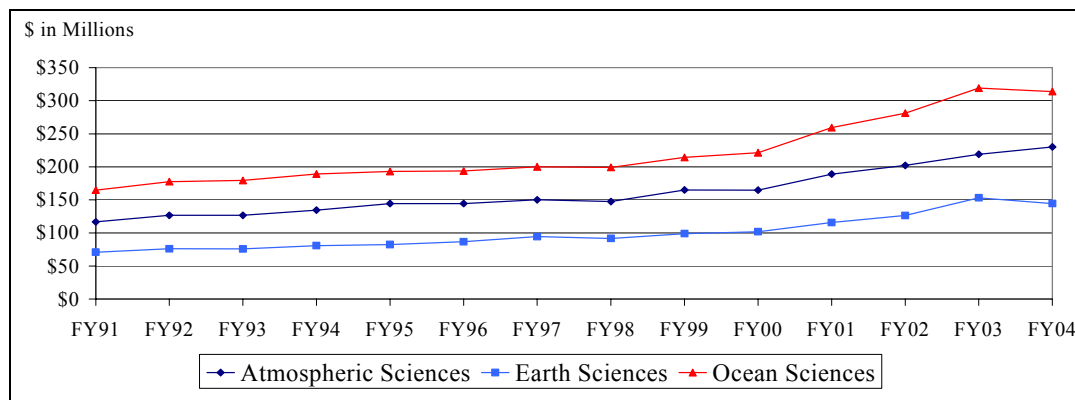
RELEVANCE

The Earth is ever-changing. Its energy input from the Sun varies; its physical and chemical structure, climate, weather, and capacity to support life change on many time scales; ocean currents shift; sea level rises and falls; continents drift; mountains build and erode; animal and plant species evolve; and terrestrial and marine ecosystems change. Most of these variations occur and will continue to occur as the result of persistent natural forces.

GEO is the principal source of federal funding for university-based basic research in the geosciences, providing about 44 percent of the total federal support in this area. GEO plays a critical role in addressing the nation's need to understand, predict and respond to environmental events and changes and to use Earth's resources wisely. Fundamental research in the geosciences advances scientific knowledge of Earth's environment, including resources such as water, energy, minerals, and biological diversity. GEO-supported activities also advance our ability to predict natural phenomena of economic and human significance, such as weather, climate change, earthquakes, fish-stock fluctuations, and disruptive events in the solar-terrestrial environment.



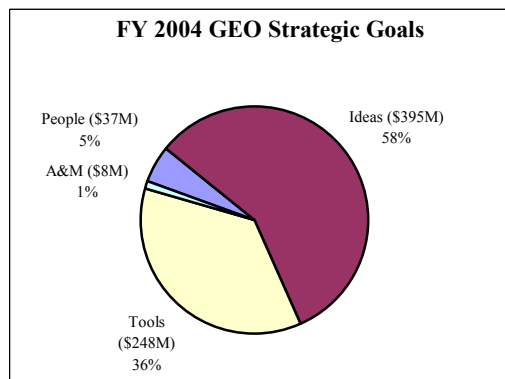
GEO Subactivity Funding



STRATEGIC GOALS

Three strategic focus areas guide GEO activities:

- **PEOPLE:** Improvement of the quality of geoscience education and training and enhancing diversity in all the fields of geoscience. GEO will advance education and training for current geoscientists, increase the diversity of the geoscience community, facilitate education and training for future generations of geoscientists, and enhance the general public’s knowledge about the integrated components of the Earth system.



- **IDEAS:** Advancement of knowledge about the Earth system, including both maintaining adequate base support across all geoscience fields and identifying opportunities where more focused support can play a catalytic role in advancing scientific progress.
- **TOOLS:** Enhancement of the infrastructure for the conduct of geoscience research. GEO will identify and make investments in instrumentation and facilities, including ships, aircraft, computers, radars, seismographs, and data management systems needed to perform world-class research.

GEO’s support for new and ongoing activities contributes to NSF’s efforts to achieve its strategic goals, and to the administration and management activities necessary to achieve these goals.

Summary of GEO Funding by Strategic Goal
(Dollars in Millions)

	FY 2002	FY 2003	FY 2004	Change	
	Actual	Estimate	Estimate	Amount	Percent
People	24.94	35.02	36.51	1.49	4.3%
Ideas	362.34	413.31	395.10	-18.21	-4.4%
Tools	217.06	234.74	248.31	13.57	5.8%
Administration & Management	5.21	8.00	8.00	0.00	0.0%
Total, GEO¹	\$609.55	\$691.07	\$687.92	-\$3.15	-0.5%

¹ FY 2003 funding includes \$74.0 million in transferred programs not re-proposed in FY 2004.

People (+1.49 million, for a total of \$36.51 million)

At NSF, placing research and learning hand in hand is our highest priority, and the people involved in our projects represent both the focus of our investments and the most important products of them. Across its programs, GEO provides support for over 10,000 people, including teachers, students, researchers, post-doctorates, and trainees. Support for programs specifically addressing NSF's Strategic Goal of "People – developing a diverse, internationally competitive and globally-engaged workforce of scientists, engineers and well-prepared citizens" totals \$36.51 million in FY 2004, an increase of \$1.49 million, or 4.3 percent, over the FY 2003 Request of \$35.02 million.

GEO People Investments
(Dollars in Millions)

	FY 2003	FY 2004	Change	
	Estimate	Estimate	Amount	Percent
K-12	5.78	6.18	0.40	6.9%
Undergraduate	11.47	11.87	0.40	3.5%
Graduate & Professional	10.77	11.46	0.69	6.4%
Other	7.00	7.00	0.00	0.0%
Total, GEO	\$35.02	\$36.51	\$1.49	4.3%

Totals may not add due to rounding.

FY 2004 highlights include:

- \$2.41 million, an increase of \$800,000 over the FY 2003 Request level of \$1.61 million, to maintain the network of coordinated centers to facilitate collaborations and communications between ocean science researchers and educators initiated in FY 2002. These Centers for Ocean Science Education Excellence (COSEE) will foster the integration of ocean research into high quality educational materials, allow ocean researchers to gain a better understanding of educational organizations and pedagogy, provide educators with an enhanced capacity to understand and deliver high-quality educational programs in the ocean sciences, and provide material to the public that will promote a deeper understanding of the ocean and its influence on each person's quality of life and our national prosperity;
- \$3.42 million, an increase of \$620,000 over the FY 2003 Request level of \$2.80 million, to support the Integrative Graduate Education and Research Training (IGERT) program, which reflects an emphasis on multidisciplinary training in all areas of NSF-supported research;

- \$2.81 million, unchanged from FY 2003, to support the Foundation-wide ADVANCE program to increase the representation and advancement of women in academic science and engineering careers; and
- \$4.0 million, unchanged from FY 2003, to support the Opportunities to Enhance Diversity in the Geosciences (OEDG) program, which seeks to increase the participation in geosciences education and research by students from groups historically underrepresented in the geosciences. A secondary goal of the program is to strengthen the understanding of the geosciences and their contribution to modern society by a broad and diverse segment of the population.

Ideas (-\$4.4 million, for a total of \$395.10 million)

Support for ideas, spanning the geosciences and encompassing a wide range of topics, totals \$395.10 million in FY 2004, a decrease of \$18.21 million, or 4.4 percent, from the FY 2003 Request of \$413.31 million. Projects in the Atmospheric Sciences Subactivity improve the understanding and prediction of climate, weather, space weather, and the global environmental system. Earth Sciences Subactivity research advances knowledge of the structure, composition, and history of the solid Earth and of the geological and hydrological processes that modify Earth. Projects in the Ocean Sciences Subactivity improve knowledge of the global climate system, coastal environments, the character of the ocean floor, as well as processes that control the chemical composition, motion, and biological production of ocean waters.

GEO will continue to participate in the Climate Change Research Initiative, with a FY 2004 investment of \$20.0 million, that doubles investments proposed in 2003 totaling \$10.0 million. Emphasis in FY 2004 will be placed on understanding the Earth's carbon cycle and advancing our ability to model dynamic multivariate systems.

In FY 2004, GEO will emphasize research on the key physical, chemical and geologic cycles within the Earth system, the characteristics and dynamics of which are of paramount importance to science and society. These activities will be complementary to, and well coordinated with, the biologically oriented studies of Earth cycles that will be carried out within the context of the Foundation-wide Biocomplexity in the Environment priority area. Specific priority activities include:

- Studies of abrupt and rapid climate change through interdisciplinary studies of ocean circulation combined with those of paleoclimate records to document the frequency, temporal resolution, and spatial extent of past rapid climate change;
- Continued examination of important biogeochemical cycles including emphasis on understanding the sources, sinks and processes which control the atmospheric abundance and distribution of carbon and water;
- Implementation of the Oceans and Human Health Initiative in partnership with the National Institutes of Health to understand the linkages between oceans and human health, including water-borne diseases, harmful algal blooms and marine pharmaceuticals;
- Multidisciplinary studies of the processes that govern water quantity and quality, the character and dynamics of the Earth's surface, and the interactive processes at the intersection of the geosphere and biosphere;
- Improving understanding of natural hazards such as floods, earthquakes, volcanic eruptions, hurricanes, and solar storms; and
- Research projects and field programs focused on understanding dynamics of the ocean mantle and its effect on the structure and evolution of the lithosphere, and on the dynamics of the atmosphere and atmospheric coupling.

GEO-supported centers include Science and Technology Centers (STCs), the Consortium for Materials Properties Research in the Earth Sciences (COMPRES), the Southern California Earthquake Center (SCEC), and Long Term Ecological Research sites (LTERs).

GEO Centers
(Dollars in Millions)

	FY 2003	FY 2004	Change	
	Estimate	Estimate	Amount	Percent
Science and Technology Centers ¹	3.21	10.69	7.48	233.0%
Consortium for Materials Properties Rsch (COMPRES)	2.50	2.70	0.20	8.0%
Southern California Earthquake Center (SCEC)	2.63	2.76	0.13	4.9%
Long Term Ecological Research Sites	1.70	1.70	0.00	0.0%
Total, GEO	\$10.04	\$17.85	\$7.81	77.8%

Totals may not add due to rounding.

¹ The increase in STC funding reflects new awards made in September 2002. These funds are shown in Integrative Activities in the FY 2003 Request, and are transferred to the appropriate managing R&RA Activity in the FY 2004 Request.

In FY 2004, GEO will support three Science and Technology Centers: the ongoing Center for Sustainability of Semi-Arid Hydrology and Riparian Areas (SAHRA), the new National Center for Earth-surface Dynamics (NCED), and the new Center for Integrated Space Weather Modeling (CISM).

GEO will continue to support the Science and Technology Center on the Sustainability of Semi-Arid Hydrology and Riparian Areas (SAHRA). The Center's scientific foci are: 1) spatial and temporal properties of hydrologic variables; 2) processes controlling water and chemical balances in catchments; 3) functioning of riparian systems; and 4) integrated modeling of catchment-scale processes. Promoting researcher-user partnerships across the breadth of water resources management through technology transfer is an integral part of the day-to-day operation of the Center. Educational initiatives contribute to sustainability by bringing water resources issues to the forefront of K-16 science education and by promoting hydrologic literacy among the public. SAHRA is educating a new generation of water resources professionals in the interdisciplinary perspective and technological skills required for practicing sustainable water resources management.

The National Center for Earth-surface Dynamics (NCED) is a Science and Technology Center focused on understanding the processes that shape the Earth's surface, and on communicating that understanding to a broad range of stakeholders. NCED's work supports a large, community-based effort to develop a suite of quantitative models of the Earth's surface: a Community Sediment Model (CSM). Results of the NCED-CSM collaboration will help solve pressing societal problems through both short-term prediction of surface response to natural and anthropogenic change and long-term interpretation of how past conditions are recorded in landscapes and sedimentary strata. NCED education and knowledge transfer programs include exhibits and educational programs at the Science Museum of Minnesota, internships and programs for students from tribal colleges and other underrepresented populations, and research opportunities for participants from outside core NCED institutions.

The Center for Integrated Space Weather Modeling (CISM) focuses its activities around building a comprehensive, physics-based, numerical simulation model that describes the space environment from the Sun to the Earth. In the course of developing this model, CISM will achieve three complementary goals: better understanding of the complex, closely coupled Sun-Earth system; transition of the results of space weather research into robust and operationally useful forecasting tools; and improved public awareness of

space weather and its effects. Model development activities will lead to new techniques for model coupling, data assimilation, and visualization. Knowledge transfer will be performed through partnerships with operational support personnel at the National Oceanic and Atmospheric Administration (NOAA) and the Department of Defense. Education and public outreach activities will be integrated with the CISM research program, and will concentrate on creating and preparing a diverse pool of qualified scientists to face space weather challenges of the future.

GEO also supports other center activities, including the Southern California Earthquake Center, the Center for Materials Properties Research, and co-funds Long Term Ecological Research sites with the Biological Sciences Activity.

The Southern California Earthquake Center (University of Southern California) has emerged as a leader in earthquake research. The Center is a regionally focused organization with the mission to gather new information about earthquakes in southern California, integrate knowledge into a comprehensive and predictable understanding of earthquake phenomena, and communicate this understanding to engineers, emergency managers, government officials, and the general public.

The Center for Materials Properties Research in the Earth Sciences (COMPRES) has emerged as a focal point for mineral-physics research and education in the U.S. The scientists of COMPRES are developing an understanding of fundamental processes within the Earth and other planets by studying natural materials at the high pressure and temperature conditions that exist in the interior of the Earth.

Long Term Ecological Research (LTER) sites support projects requiring long periods of study; the sustained nature of studies allows scientifically sound evaluations of major environmental phenomena. The LTERs represent many disciplines that enhance our understanding of general ecological phenomena that occur over long temporal and broad spatial scales, provide information for the identification and solution of environmental problems, and enable interdisciplinary collaborative activities.

Priority Areas

In FY 2004, GEO will support research and education efforts related to broad, Foundation-wide priority areas in Biocomplexity in the Environment, Information Technology Research, Nanoscale Science and Engineering, Mathematical Sciences, and Human and Social Dynamics.

GEO Investments in Priority Areas
(Dollars in Millions)

	FY 2002 Actual	FY 2003 Request	FY 2004 Request	Change	
				Amount	Percent
Biocomplexity in the Environment	23.00	22.22	37.22	15.00	67.5%
Information Technology Research	12.16	13.21	14.56	1.35	10.2%
Nanoscale Science and Engineering	6.80	7.53	7.88	0.35	4.6%
Mathematical Sciences	N/A	4.57	7.07	2.50	54.7%
Human and Social Dynamics	N/A	N/A	1.35	1.35	N/A

Biocomplexity in the Environment: In FY 2004, GEO will provide \$37.22 million, an increase of \$15.0 million over the FY 2003 Request of \$22.22 million, to support the NSF-wide Biocomplexity competition and a set of coordinated activities in environmental science, engineering and education that advance

scientific knowledge about the connection between the living and non-living Earth system. These funds will enable the continuation of four interdisciplinary activities:

- Planetary Ecology focuses on understanding the Earth's marine and terrestrial ecosystems and their evolution, and the interaction of the biosphere with earth system processes. GEO will support research focused on microbial habitats in the terrestrial and submarine deep subsurface to study processes including: biologically controlled mineralization, the production of gas hydrates, microbiological controls on seawater chemistry and productivity, and soil and rhizosphere processes. Included is \$4.0 million to study the ecology of infectious diseases;
- Planetary Metabolism aims to understand the links and feedbacks among the Earth's physical, chemical, geological, and biological, as well as social, systems; how they have evolved; and how they affect the planet's biosphere and geosphere;
- Planetary Energetics and Dynamics attempts to understand the links between physical and biochemical processes by focusing on energy exchange. This includes an effort to understand, mitigate and predict natural hazards – for example, hurricane genesis and storm tracking, earthquake nucleation, and energetic processes in the upper atmosphere; and
- Earth Observatories will make sustained time-series observations to understand the temporal evolution of environmental systems that are central to the study of biocomplexity in the environment.

Information Technology Research: In FY 2004, GEO will provide \$14.56 million, an increase of \$1.35 million over the FY 2003 Request of \$13.21 million, to support information-based activities that focus on:

- Development of comprehensive coupled models that include ensemble forecasting, nesting and/or data assimilation techniques to understand the complex interactions taking place in the Earth system;
- Development of tools for knowledge discovery, visualization and interpretation of large-scale heterogeneous data sets;
- Development of the infrastructure to find, access, retrieve, and integrate geospatial data from distributed, heterogeneous sources in a way that makes them useful for scientific research; and
- Extension of local networking and computing capabilities in support of large-scale modeling and database activities in the geosciences.

Nanoscale Science and Engineering: In FY 2004, GEO will support Nanoscale Science and Engineering at a level of \$7.88 million, an increase of \$350,000 over the FY 2003 Request of \$7.53 million, for activities that focus on:

- The development and application of chemical and biological sensor technology for making rapid, high-precision observations at submicroscopic spatial and volumetric scales;
- Support for crosscutting studies aimed at understanding the distributions and behavior of nanoscale structures throughout the Earth, atmosphere, and oceans; and
- The development of heavily instrumented interdisciplinary Earth System Observatories that facilitate our understanding of nanoscale geoscience processes, including platforms to detect and characterize nanoscale particles and their interactions throughout the atmosphere and oceans.

Mathematical Sciences: In FY 2004, GEO will support multidisciplinary research involving the partnering of mathematicians and geoscientists to investigate topics spanning the earth, atmospheric, and ocean sciences at a level of \$7.07 million, an increase of \$2.50 million over the FY 2003 Request of \$4.57 million.

Human and Social Dynamics: In FY 2004, GEO will initiate participation in the Human and Social Dynamics priority area at a level of \$1.35 million to engage the social science community in understanding and predicting behavior in response to extreme events (earthquakes, hurricanes, tornados, solar disruptions, etc.) and other natural processes affecting society.

Tools (+13.57 million, for a total of \$248.31 million)

The GEO Activity supports user facilities necessary for the conduct of research in the geosciences. These include large national user facilities such as the National Center for Atmospheric Research (NCAR) and the U.S. academic fleet, and smaller facilities in the atmospheric, earth, and ocean sciences.

GEO Investments in Tools
(Dollars in Millions)

	FY 2003	FY 2004	Change	
	Estimate	Estimate	Amount	Percent
Academic Research Fleet/Ship Operations	62.00	65.00	3.00	4.8%
EarthScope Operation	0.00	1.00	1.00	N/A
Incorporated Research Institutions for Seismology	13.10	14.10	1.00	7.6%
National Center for Atmospheric Research	73.60	78.82	5.22	7.1%
Ocean Drilling Program Operations	30.00	8.40	-21.60	-72.0%
Digital Library	2.90	4.20	1.30	44.8%
Research Resources	20.79	20.79	0.00	0.0%
Other GEO Facilities ¹	32.35	56.00	23.65	73.1%
Total, Facilities Support	\$234.74	\$248.31	\$13.57	5.8%

¹Other GEO facilities include multi-user accelerator-based mass spectrometers, synchrotron beamlines, radar facilities to study weather and the upper atmosphere (including the National Astronomy and Ionosphere Center), facilities to support the scientific use of the Global Positioning System, and activities related to the Integrated Ocean Drilling program.

NSF support provides for ongoing operations and maintenance, including upgrades to existing facilities as well as regularly scheduled repairs. FY 2004 plans include:

- \$78.82 million, an increase of \$5.22 million, or 7.1 percent, over the FY 2003 Request of \$73.60 million, for the operation and maintenance of observational and computer facilities at NCAR. NCAR is a world-renowned center for atmospheric research that makes facilities available – including supercomputers, instrumented research aircraft and ground-based portable observing systems – to scientists at universities, NCAR, and elsewhere. In FY 2004 NCAR will focus on: research on Earth's natural cycles, including climate system modeling and the operation of the computation facilities for the Climate Simulation Laboratory; projects within the U.S. Weather Research Program (USWRP) and the National Space Weather Program (NSWP), which aim to achieve a better understanding and improved predictive capability of costly and disruptive storms on Earth and in space; and continued development of observational and computational capabilities;
- \$8.40 million, a decrease of \$21.60 million, or 72.0 percent, from the FY 2003 Request of \$30.0 million, to support core storage and data distribution infrastructure associated with the Ocean Drilling Program (ODP). In 2003, the *Resolution* will complete its contracted drilling operations for the ODP, with research cruises examining the formation of ocean crust produced by rapid periods of sea-floor spreading in the eastern Pacific, and by extremely slow periods of spreading in the central Atlantic. Additional drilling cruises in the south Atlantic will examine the Mesozoic-Cenozoic history of ocean circulation by drilling sediments along the Brazilian and African continental margins. Finally, the ODP will address the geologic processes during continental rifting through recovery of sediment and crustal rock off Newfoundland. A follow-on international program, the Integrated Ocean Drilling Program, is being developed, and is discussed under Other Geosciences Facilities.

- \$65.0 million, an increase of \$3.0 million, or 4.8 percent, over the FY 2003 Request of \$62.0 million, for the continued operation of the U.S. Academic Research Fleet. Approximately 325 projects with about 2,500 scientists and students will use the fleet's 27 ships. The projects range from individual investigator studies of coastal waters to integrated multi-investigator studies of global ocean processes. NSF-funded researchers are the primary users of the ships, accounting for about 65 percent of their total use. NSF ship operation funds support the costs associated with the use of the fleet by these researchers;
- \$14.10 million, an increase of \$1.0 million, or 7.6 percent, over the FY 2003 Request of \$13.10 million, to continue support for the Incorporated Research Institutions for Seismology (IRIS). IRIS facilities provide rapid analysis of earthquakes, aid in monitoring nuclear proliferation, and permit imaging of the internal physical structure of Earth;
- \$1.0 million will initiate preliminary operation of the EarthScope facility. EarthScope, construction of which is funded through the Major Research Equipment and Facilities Construction Account, is a distributed, multi-purpose geophysical instrument array that will make major advances in our knowledge and understanding of the structure and dynamics of the North American continent.
- \$56.0 million, an increase of \$23.65 million, or 73.1 percent, over the FY 2003 Request of \$32.35 million, for Other Geosciences Facilities, which includes facilities to support the use of the Global Positioning System for scientific research, multi-user analytical facilities such as accelerator-based mass spectrometers, synchrotron beamlines, and operation, upgrade, development, and construction of radar facilities to study precipitation and upper atmospheric phenomena. Of particular note is the initiation of support to develop a new deep submergence capability, expected to total approximately \$12.50 million in FY 2004 depending on recommendations from the National Academy of Sciences expected in late FY 2003. FY 2004 sees growth in the new Integrated Ocean Drilling Program (IODP), with \$7.0 million being used to facilitate planning for U.S. participation in the new program. Major Research Equipment and Facilities Construction (MREFC) Account funding for conversion, outfitting and acceptance trials of a deep-sea drilling vessel is planned to begin in FY 2005. Further information on the Scientific Ocean Drilling project of the IODP can be found in the MREFC chapter. Finally, in FY 2004 construction of the Advanced Modular Incoherent Scatter Radar (AMISR) will continue at a level of \$12.50 million, pending National Science Board approval in FY 2003.

Administration and Management

Administration and Management provides for administrative activities necessary to enable NSF to achieve its strategic goals. Requested funding for FY 2004 is \$8.0 million, level with FY 2003. This includes the cost of Intergovernmental Personnel Act appointments and contractors performing administrative functions.

QUALITY

GEO maximizes the quality of the R&D it supports through the use of a competitive, merit-based review process. In FY 2002, the last year for which complete data exist, 76 percent of basic and applied research funds were allocated to projects that undergo merit review. OMB's definition of competitive, merit-based review does not include Federally Funded Research and Development Centers; therefore support for the National Center for Atmospheric Research, although regularly merit reviewed, is not considered as funding that undergoes competitive, merit-based review for this calculation.

To ensure the highest quality in processing and recommending proposals for awards, GEO convenes Committees of Visitors, composed of qualified external evaluators, to review each program every three years. These experts assess the integrity and efficiency of the processes for proposal review and provide a retrospective assessment of the quality of results of NSF's investments.

The Geoscience Activity also receives advice from the Advisory Committee for Geosciences (AC/GEO) on such issues as: the mission, programs, and goals that can best serve the scientific community; how GEO can promote quality graduate and undergraduate education in the geosciences; and priority investment areas in geoscience research. AC/GEO meets twice a year and members represent a cross section of the geosciences with representatives from many different sub-disciplines within the field; a cross section of institutions including industry; broad geographic representation; and balanced representation of women and traditionally under-represented minorities.

PERFORMANCE

Several recent activities highlight the successes of past investment in the geosciences:



Thomas Windham, University Corporation for Atmospheric Research, ATM 00-90060

The University Corporation for Atmospheric Research's mentoring program, Significant Opportunities in Atmospheric Research and Science (SOARS), was selected as one of ten institutions receiving the sixth annual Presidential Award for Excellence in Science, Mathematics, and Engineering Mentoring. The award recognizes ten institutions and ten individuals for promoting participation among women, minorities, and persons with disabilities in scientific and engineering careers. The Presidential Award for Excellence in Science, Mathematics, and Engineering Mentoring is administered and funded through NSF and goes to people and institutions who work with students in K-12, undergraduate, or graduate-level education.

Now in its sixth year, SOARS is designed to interest students from traditionally underserved communities in academic degrees and careers in atmospheric science and its related fields. SOARS is a year-round program that includes a ten-week paid internship each summer. Protégés have come from over 40 participating universities and colleges.



Raymond W. Schmitt, James R. Ledwell, John M. Toole, Kurt L. Polzin, Woods Hole Oceanographic Institute, OCE 00-81502;

The decades-old problem of ocean mixing took one step closer to resolution with the recent results reported from the Salt Finger Tracer Experiment (SFTRE). Researchers from WHOI injected an inert tracer (SF_6) into a stable layer between two layers of salt fingers, bodies of water with distinct heat and salt content, and returned almost a year later to find the dye had mixed more than 120 meters above and below the release level, 10X greater than what could be induced turbulent mixing (currents and eddies). This thermodynamically driven process, speculated upon for years but never proven, provides a much-needed explanation of mixing between cold, fresh waters and warm, saltier water. (*Science*, 2002. 295:1821)

M. Meghan Miller, Central Washington University, EAR 96-15640

Dr. M. Meghan Miller and her colleagues at Central Washington University recently reported discovery of a repeating pattern of slow earthquakes along the Cascadia subduction zone. Slow earthquakes are caused by slip along a fault but, unlike more familiar earthquakes that cause rapid ground movements, fault slip occurs over hours to months. These curious transient events have been recognized in several seismically active regions around the world, but this is the first report of a repeating pattern. The Central Washington University team found that the slow earthquakes occur on average every 14.5 months over the ten-year observation period, last about 8 weeks, and are the equivalent of a magnitude 6.7 (moment magnitude) earthquake.

The mechanisms of repeating pattern are not yet understood. Miller and co-worker T. Melbourne will be pursuing that question as part of new research project to begin this summer. Some researchers think slow earthquakes may quietly release energy on the Cascadia subduction whereas others are concerned the slow events may trigger a large catastrophic earthquake. In either case, the new discovery may lead to better understanding of the earthquake cycle in this heavily populated region where large devastating earthquakes seem to occur about every 500 years.



Albert M. Bradley and Dana R. Yoerger, Woods Hole Oceanographic Institute, OCE 97-30690

The Autonomous Benthic Explorer (ABE) is the first vehicle of its kind. This vehicle was developed because of scientists' frequent need to monitor an area over long periods of time, which is very expensive using a surface ship with submersibles such as Alvin. ABE is a true robot, able to move on its own with no pilot or tether to a ship, designed to perform a predetermined set of maneuvers to take photographs and collect data and samples within an area about the size of a city block. It

will then “go back to sleep,” conserving power for months of repeating these tasks. A team of engineers at the Woods Hole Oceanographic Institution developed ABE to follow a set of instructions placed in its memory before deployment. After a mission these data are downloaded, however, its developers envision that in the future underwater acoustic transmission systems now being developed will allow scientists anywhere in the world to receive video and data from ABE and to control its movement and measurements from their home laboratories. This year ABE played a major role in the Dive and Discover program that was funded in part by NSF. As part of this program ABE produced highly detailed maps of seafloor that were used to search for hydrothermal vents.



John Kelly, SRI International, ATM 00-89937

Advanced Modular Incoherent Scatter Radar (AMISR)

SRI International has constructed a small array of antenna elements for testing a new concept in incoherent scatter radar design. The tests are to demonstrate the feasibility of constructing a large phased-array that can easily be disassembled and moved to different locations. The most basic element in the AMISR design is the Antenna Element Unity (AEU), which consists of a power amplifier, polarization and transmit/receive circuitry, an antenna, a low noise amplifier, calibration paths, and control and monitoring electronics. Thirty-two identical AEU's are placed in fixed locations on a panel, with the locations determined by the desired grating lobe-free

scanning of the final antenna. A single panel thus represents the minimum-size phased array antenna, with multiple panels typically combined to form a face.

Two panels were constructed and shipped to an Air Force antenna testing facility in Massachusetts. The panels were later shipped to a remote site in Alaska for testing. Test results show that the radar is working very close to design specifications. SRI is beginning design for manufacturing in anticipation of mass-producing the antenna units to build large, transportable incoherent scatter radars for deployment at scientifically strategic locations.

Other Performance Indicators

The tables below show the growth in the number of people benefiting from GEO’s funding, and trends in growth of award size, duration and number.

Number of People Supported in GEO Activities

	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate
Senior Researchers	3,652	4,290	4,290
Other Professionals	2,404	2,750	2,750
Postdoctorates	574	660	660
Graduate Students	2,040	2,530	2,530
Undergraduate Students	1,139	1,600	1,600
K-12 Students			
K-12 Teachers			
Total Number of People	9,809	11,830	11,830

GEO Funding Profile

	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate
Number of Requests for Funding	5,063	5,800	6,000
Dollars Requested (in millions)	\$2,851	\$2,640	\$2,730
Total Number of Awards	2,929	3,310	3,300
Statistics for Competitive Awards:			
Number	1,450	1,620	1,620
Funding Rate	35%	39%	37%
Statistics for Research Grants:			
Number of Research Grants	1,112	1,230	1,200
Median Annualized Award Size	\$80,168	\$82,246	\$85,000
Average Annualized Award Size	\$103,449	\$104,246	\$107,000
Average Award Duration, in years	2.8	3.0	3.0

Program Assessment Rating Tool (PART)

A new performance assessment undertaken in FY 2002 was the Program Assessment Rating Tool (PART). The PART assesses program performance in four areas: Program Purpose and Design, Strategic Planning, Program Management and Program Results. During formulation of the FY 2004 Budget, OMB completed PARTs on select programs for each agency. Two “programs” at NSF were assessed – the TOOLS strategic outcome goal and the Geosciences Activity.

Overall, GEO received a score of 81 percent (out of a possible 100 percent) and a rating of Moderately Effective. With respect to program purpose and design, the PART review found that GEO has a clear purpose and is designed to make a unique contribution. It is the principal source of federal funding for university-based basic research in the geosciences. The program is optimally designed, utilizing the competitive merit-review process to allocate the vast majority of its basic and applied research funds.

With respect to strategic planning, the assessment found that that NSF’s annual goals are too broad to be useful in tracking how GEO will improve scientific understanding and its application. NSF will consider a revision of annual goals following the agency’s revision of its Strategic Plan. It was noted that GEO collaborates and coordinates effectively with other agencies that share similar goals and objectives. Independent evaluations, such as Committee of Visitor reviews and Directorate Advisory Committee assessments are conducted regularly in order to inform program improvements and influence program planning.

The PART assessment indicates that NSF still needs to make progress in aligning program budgets with program goals so that the impact of funding, policy and legislative changes on performance can be readily assessed.

The PART assessment recognizes that GEO utilizes information on both management goals and grantee achievements to manage and guide future directions. All funds are obligated in a timely manner. NSF uses strong financial management practices and takes steps to address identified deficiencies. GEO has demonstrated adequate progress in achieving NSF’s long-term outcome goals – PEOPLE, IDEAS and TOOLS. GEO’s performance is effective and compares favorably to other programs with similar purpose and goals.

Finally, defining GEO as a program for the purpose of the PART analysis was not very useful, since primary budget decisions were not made at the Directorate level. The Administration will likely not use Directorates as a category for future PART assessments.

ATMOSPHERIC SCIENCES

\$229,920,000

The FY 2004 Request for the Atmospheric Sciences Subactivity is \$229.92 million, an increase of \$11.0 million, or 5.0 percent, above the FY 2003 Request of \$218.92 million.

Atmospheric Sciences Funding
(Dollars in Millions)

	FY 2002 Actual	FY 2003 Request	FY 2004 Request	Change Amount	Change Percent
Atmospheric Sciences Research Support	125.83	145.32	151.10	5.78	4.0%
National Center for Atmospheric Research	76.32	73.60	78.82	5.22	7.1%
Total, ATM	\$202.15	\$218.92	\$229.92	\$11.00	5.0%

Totals may not add due to rounding.

Research in the Atmospheric Sciences Subactivity (ATM) furthers our understanding of weather, climate, and the solar-terrestrial system by expanding the fundamental knowledge of the composition and dynamics of Earth's atmosphere and geospace environment. Almost 40 percent of the funds for ATM support the operation and maintenance of large, complex facilities required for research in the atmospheric and solar-terrestrial sciences. These facilities are shared by the atmospheric science community for fundamental research by individuals and groups of investigators participating in national and international scientific field programs and experiments.

Recent research supported by NSF included one of the largest weather-related studies in U.S. history. The International H₂O Project (IHOP) tracked water vapor across the southern Great Plains from Texas to Kansas in order to improve predictions of timing, location, and intensity of summertime storms. Led by University and NCAR scientists, IHOP2002 was based in central Oklahoma from May 13 to June 25, 2002. The National Science Foundation provided the bulk of the project's \$7.0 million funding, with additional support from other agencies.

Better precipitation outlooks are a key goal of the U.S. Weather Research Program, which has organized a number of agencies in support of IHOP. The study, involving over 100 scientists and technicians, aimed to improve forecasts from 1 to 12 hours ahead of heavy rain, which could help in flash-flood safety and other applications. Six aircraft from the United States and Germany participated. A futuristic, semi-autonomous research craft, the Proteus (sponsored by NASA, NOAA and DOD), carried instruments up to 56,000 feet. In addition, 30 weather-tech vehicles, including four Doppler radars on flatbed trucks, participated on the ground in Oklahoma, Kansas, and Texas.

One of the key technologies for determining the solar contribution to Global Change is accurate measurement of the solar diameter. The main difficulties with precise measurement of the solar diameter are: (1) the atmospheric "seeing" is systemic and one cannot simply decrease its effects by making the same measurement several times, (2) the solar diameter is large in angular terms and is affected by optical aberrations that increase with distance from the optical axis, and (3) calibration is difficult. NSF-supported scientists have developed a balloon-borne instrument called the Solar Disk Sextant (SDS), which largely circumvents each of these difficulties through innovative design and by observing the sun from the 3-mbar pressure level of the atmosphere. Flights of the instrument have been made from Fort Sumner, New Mexico, in the fall of 1992, 1994, 1995, 1996 and 2001. The principal objective of the work is to understand the details of the physical mechanism for solar variability on decades to centuries, and to measure and understand the logarithmic derivative of the solar radius with respect to luminosity.

Once this is determined, historical eclipse data extending back for some 250 years (which provide the solar radius) can be inverted to deliver to infer the solar luminosity for this entire time period.

The FY 2004 Budget Request includes \$151.10 million for Atmospheric Sciences Research Support, which provides funding for individual and group research projects in physical meteorology, large-scale dynamic meteorology, experimental meteorology, climate dynamics, atmospheric chemistry, aeronomy, magnetospheric physics and solar-terrestrial relations. Research studies develop the scientific basis for understanding the dynamic and physical behavior of climate and weather on all scales, the natural global chemical cycles of gases and particles in Earth's atmosphere, the composition, energetics, and particularly the dynamics of the coupled upper atmospheric system, and the sun as it relates to Earth's upper atmosphere and space environment. Support is also provided for lower atmospheric facilities at several universities and for upper atmospheric observatories in Massachusetts, Puerto Rico, Greenland and Peru that are operated by U.S. universities and research institutions. Also included is support for Unidata, a national program to help universities use computing technology and atmospheric data for teaching and research. Highlights for FY 2004 include:

- Continued examination of important biogeochemical cycles including emphasis on understanding the sources, sinks and processes which control the atmospheric abundance and distribution of carbon, water and other nutrient elements;
- Development of improved computer systems and numerical models, smart instrumentation, and collaborations which will allow new discoveries, greater access to atmospheric data, and improved understanding of the atmospheric environment which will be supported as part of the ITR priority area;
- Support for new environmental modeling that employ data assimilation and innovative mathematic and statistical techniques to improve predictions of fundamental atmospheric and Earth system processes;
- Continued support of the U.S. Weather Research Program, the National Space Weather Program, disciplinary research and cooperative international science programs; and
- Continued development and construction of the Advanced Modular Incoherent Scatter Radar, a next-generation upper atmospheric observational system. This system will eventually provide key data to further our understanding of space weather and, thereby, to mitigate society's vulnerability to space storms.

FY 2004 support for the National Center for Atmospheric Research (NCAR) totals \$78.82 million. During FY 2004 NCAR will focus on:

- Research in the atmospheric and related sciences, including climate system modeling and the operation of the computation facilities for the Climate Simulation Laboratory;
- The U.S. Weather Research Program and the National Space Weather Program, which aim to achieve a better understanding and improved predictive capability of costly and disruptive storms on Earth and in space; and
- Continued support and development of new and improved observational and computational capabilities.

EARTH SCIENCES

\$144,260,000

The FY 2004 Request for the Earth Sciences Subactivity is \$144.26 million, a decrease of \$8.88 million, or 5.8 percent, from the FY 2003 Request of \$153.14 million.

Earth Sciences Funding
(Dollars in Millions)

	FY 2002	FY 2003	FY 2004	Change	
	Actual	Request	Request	Amount	Percent
Earth Sciences Project Support	95.38	116.94	109.16	-7.78	-6.7%
Instrumentation and Facilities	30.90	36.20	35.10	-1.10	-3.0%
Total, EAR	\$126.27	\$153.14	\$144.26	-\$8.88	-5.8%

Totals may not add due to rounding.

The Earth Sciences Subactivity (EAR) supports research and educational activities designed to improve our understanding of processes that govern the behavior and characteristics of the Earth’s surface environment and determine its internal structure, composition and dynamics. Funding is provided for theoretical, computational, laboratory and field studies, and for state-of-the-art scientific infrastructure needs. The new understanding gained from such studies provides the scientific basis for 1) the prediction of natural hazards such as earthquakes, volcanic eruptions, floods and droughts, and the mitigation of their impacts; 2) the discovery and management of mineral, energy, and water resources; and 3) for environmentally sound decision-making. Supported projects often occur in partnership with and complement focused efforts by other federal and state agencies. EAR plays a crucial role in advancing both research and education in the Earth Sciences.

EAR is increasing its support of educational activities. These activities are emerging at a time when there is growing national awareness of the need to improve science education and an appreciation of the opportunities offered by the Earth Sciences to engage students of all levels in the exploration of the world around them. With strong encouragement and support, education activities have become an integral part of EAR facilities and research programs. The Consortium of Universities for the Advancement of the Hydrologic Sciences (CUAHSI), for example, is developing a focused education and outreach effort for the water sciences. CUAHSI has embraced the integration of research and education. A central emphasis of this emerging consortium will be outreach to the educational community and the general public through activities designed to provide an understanding and appreciation for water resources and associated science and technology.

Educational and public outreach activities are also linked to the research activities of the new EarthScope facility. By working at both the national and local levels, the EarthScope effort will focus on (1) resource development and dissemination, and (2) program development and implementation. Resource development and dissemination includes creating public educational information, posters, fact sheets, and news releases; producing educational videos; developing curriculum resources and visualization and analysis tools; and sponsoring museum exhibits. Program development and implementation activities include formal education activities such as teacher professional development, and informal education activities at parks and community centers. This philosophy exemplifies EAR's intention to impact education nationally but also locally through engaging our EAR researchers in broader educational endeavors.

The FY 2004 Budget Request includes \$109.16 million for Earth Sciences Project Support to provide funds for three main activities. The first is support for individuals and groups of scientists whose research provides the foundation of excellence and capability across all disciplines of the Earth Sciences. Supported programs include disciplinary studies in geology, paleontology, geophysics, geochemistry, and the hydrologic sciences. The second is support for interdisciplinary research to help understand the parameters and processes that govern the behavior of complex global systems and gain insight into the character and behavior of the Earth's environment. This funding will enable continued support for U.S. scientists and engineers to participate in coordinated national and international research activities as well as an increased emphasis on natural hazards, the water sciences and collaborative multidisciplinary studies to understand the Earth as a functioning dynamic system. The third is the integration of research, education and public awareness through the support of outreach projects, digital libraries and other human resources activities within the geosciences. Priorities for FY 2004 include support for:

- Multidisciplinary studies of the hydrological and biogeochemical cycles, processes that govern water quantity and quality, the character and dynamics of the Earth's surface, and the interactive processes at the intersection of the geosphere and biosphere;
- Improving understanding of natural hazards such as floods, earthquakes and volcanic eruptions;
- Implementation of the EarthScope geophysical and geodetic observational capabilities of the Earth Sciences in order to better understand the physics of earthquakes and the structure, dynamics and evolution of the North American continent;
- Expanding capabilities for computationally challenging planetary research such as dynamic modeling of Earth system processes, managing very large data sets, and integrating and synthesizing data between disciplines while meeting interagency information technology goals; and
- Enabling national and international continental scientific drilling focusing on the mechanics of earthquake initiation, and the detailed mechanisms that control eruptive volcanism.

Support for the Instrumentation and Facilities Program and infrastructure activities totals \$35.10 million. This supports shared research facilities such as Incorporated Research Institutions for Seismology (IRIS) for seismological research, the University Navstar Consortium (UNAVCO) for precision geodetic measurements using Global Positioning Systems (GPS), accelerator-based mass spectrometers, ion-beam microprobes, and synchrotron beam lines. The program also funds the research and educational needs for instrumentation and computational infrastructure at universities and colleges throughout the nation. Priorities for FY 2004 include support for:

- Through the EarthScope facilities, enhancement of seismic, geodetic and other geophysical observational platforms on the North American continent to obtain unprecedented resolution imaging of Earth structures underneath the continent and improved understanding of earthquakes, volcanic eruptions and related active tectonic processes;
- Development and deployment of ultra-high pressure technology enabling laboratory investigations of Earth and other planetary bodies under extreme conditions existing in deep planetary interiors;
- The IRIS facility, to enhance operation and deployment of the Global Seismic Network for deep earth research and monitoring associated with nuclear nonproliferation and verification, continue making available portable seismic arrays to facilitate focused geophysical research, and to sustain the Data Management System which makes available data on seismic events to researchers world-wide; and
- Development of a dedicated InSAR (Interferometric Synthetic Aperture Radar) satellite mission, carried out jointly with partner agencies, to provide spatially-continuous strain measurements over wide geographic areas.

OCEAN SCIENCES

\$313,740,000

The FY 2004 Request for the Ocean Sciences Subactivity is \$313.74 million, a decrease of \$5.27 million, or 1.7 percent from the FY 2003 request of \$319.01 million.

Ocean Sciences Funding
(Dollars in Millions)

	FY 2002	FY 2003	FY 2004	Change	
	Actual	Request	Request	Amount	Percent
Oceans Section	104.04	120.01	115.76	-4.25	-3.5%
Integrative Programs Section	93.64	104.00	104.08	0.08	0.1%
Marine Geosciences Section	83.44	95.00	93.90	-1.10	-1.2%
Total, OCE	\$281.12	\$319.01	\$313.74	-\$5.27	-1.7%

Totals may not add due to rounding.

The Ocean Sciences Subactivity (OCE) supports research to improve knowledge of the physical, chemical and biological processes that characterize both coastal seas and deep ocean basins, and the geological and geophysical processes that shape the continental shelves and deep sea floor. Support is also provided for the facilities required to gain access to the ocean, including research vessels, manned deep diving submersibles and a wide range of technologically advanced observational instrumentation. Oceanography is a highly interdisciplinary research endeavor that is fundamental to the understanding of the Earth's climate, to resource and hazard assessment, and to the health of the ocean's complex and diverse ecological systems.

Recent discoveries demonstrate that the ocean has much yet to reveal. Recent studies using cores collected by the Ocean Drilling Program provide a landmark change in our understanding of deep-ocean circulation. During the transition from the most recent glacial conditions (~20,000 years ago) to the more recent interglacial period, the most important source of salt for deep ocean waters switched from the Antarctic to the North Atlantic. Deep ocean circulation is a key process affecting the global heat budget, and this discovery has profound implications for modeling studies of the glacial climate.

The FY 2004 Request includes \$115.76 million, a decrease of \$4.25 million from the FY 2003 Request of \$120.01 million, for Oceans Section research support. Studies span a wide range of research topics involving processes occurring within the water column from the air/sea interface to the ocean floor. Research problems increasingly require focused, collaborative, and coordinated programs of observation and interpretation that are often interdisciplinary. Projects range from individual investigator laboratory-based work to multi-investigator collaborations and international programs that require substantial amounts of ship-time and other facility resources. Priorities for FY 2004 include support for:

- Increased attention for studies of abrupt and rapid climate change through interdisciplinary studies of ocean circulation combined with those of paleoclimate records to document the frequency, temporal resolution, and spatial extent of past rapid climate change;
- Implementation of the Oceans and Human Health Initiative (with NIH) to understand the linkages between oceans and human health, including vector and water-borne diseases, harmful algal blooms and marine pharmaceuticals;
- Studies of marine biocomplexity, particularly marine ecosystems at all levels of organization from functional genomics of marine organisms at the molecular level to open ocean non-linear processes;
- Continued development of capabilities for data assimilation and modeling for ocean circulation and biogeochemical flux studies, resulting from a growing history of sustained time-series observations;

- Encourage interdisciplinary collaborations between mathematicians, statisticians and geoscientists to develop new approaches to solve problems and provide new insights in quantitative oceanography;
- Research to identify, understand, and quantify the processes controlling carbon cycling in the oceans; and
- Enhanced long-term process studies of deep ocean and coastal systems using sustained time-series observations, and development of new technology for ocean and seafloor observation systems.

The Integrative Programs Section totals \$104.08 million, an increase of \$80,000 over the FY 2003 Request of \$104.0 million, and coordinates critical functions integral to the Ocean Sciences Subactivity. They include education and diversity programs, ship operations, upgrades, construction, instrumentation, technical services, and oceanographic facilities, new technology development, ocean observatories and observation systems, the National Oceanographic Partnership Program (NOPP) and its emerging OCEANS.US coordination office. Priorities for FY 2004 include:

- Replacement and enhancement of deep submergence capabilities using the results of an National Research Council study to guide plans for replacing the 38-year old submersible ALVIN;
- Development of concept designs for new Regional Class vessels as part of the Federal Oceanographic Facilities Committee's (FOFC) plan for renewal of the academic fleet;
- The academic research fleet to ensure that required ship time and capabilities are provided to satisfy merit reviewed research project requirements for NSF-sponsored studies;
- Enhancement of technical and shared-use instrumentation for projects for sea-going scientists;
- Continued maintenance and ship-improvement programs and increased support for quality improvement activities in operations and technical services programs; and
- Technology development, particularly for smart environmental sensors and the design of infrastructure to support seafloor observatories.

The Marine Geosciences Section totals \$93.90 million, a decrease of \$1.10 million from the FY 2003 Request of \$95.0 million, and supports research to improve fundamental understanding of the composition, structure and evolution of the oceanic crust and continental margins; the record of global environmental and biologic change; and geochemical cycling produced by plate tectonic processes and fluid flow in sedimentary and crustal rock. This includes support for core research in marine geology, geochemistry and geophysics; coordinated community initiatives focused on thematic priorities in planetary dynamics and earth system cycles; and U.S. management and participation in the Ocean Drilling Program (ODP), which is jointly financed with seven international partners. Planning and preparations for the Integrated Ocean Drilling Program (IODP) are high priorities. Additional priorities for FY 2004 include support for:

- Research projects and field programs focused on understanding dynamics of the ocean mantle and its effect on the structure and evolution of the lithosphere;
- Increased use of observatory instrumentation and experiments at integrated ridge crest study sites to evaluate biological and hydrothermal dynamics and their roles in planetary metabolism and ecology;
- Integrated observational, laboratory and theoretical studies of continental rifting process in coordination with the Earth Sciences subactivity, and
- Coordinated geologic, geochemical, geophysical and drilling studies of fluid flow in ocean crust and continental margin sediments.