

GEOSCIENCES

\$848,670,000

The FY 2009 Budget Request for the Directorate for Geosciences (GEO) is \$848.67 million, an increase of \$96.01 million, or 12.8 percent, over the FY 2008 Estimate of \$752.66 million.

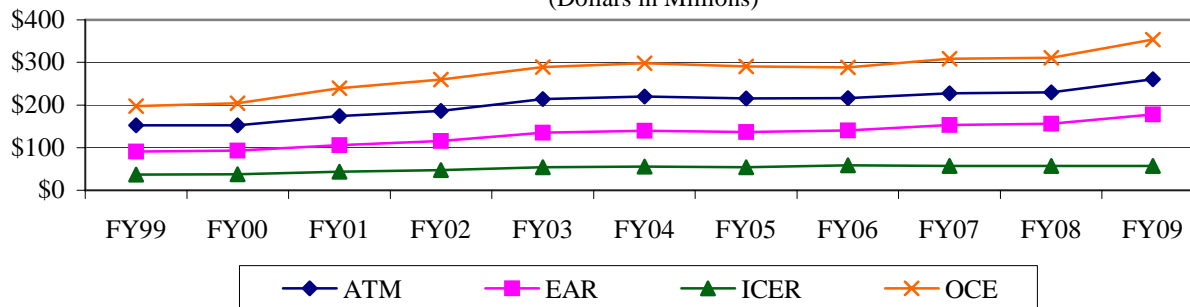
Geosciences Funding
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change Over FY 2008 Estimate	
				Amount	Percent
Atmospheric Sciences (ATM)	227.44	229.30	260.58	31.28	13.6%
Earth Sciences (EAR)	152.83	156.08	177.73	21.65	13.9%
Innovative & Collaborative Education & Research (ICER)	56.82	56.82	56.82	-	-
Ocean Sciences (OCE)	308.76	310.46	353.54	43.08	13.9%
Total, GEO	\$745.85	\$752.66	\$848.67	\$96.01	12.8%

Totals may not add due to rounding.

As the principal source of federal funding for university-based fundamental research in the geosciences, the Directorate for Geosciences addresses the Nation's need to understand, predict, and respond to environmental events and changes. GEO-supported research also advances our ability to predict natural phenomena of economic and human significance, such as climate changes, hurricanes, fish-stock fluctuations, earthquakes, and disruptive events in the solar-terrestrial environment. **GEO is NSF's lead partner in the U.S. Global Change Research Program, and plays a critical role in advancing our understanding of the basic drivers of global environmental change and the Earth's responses.**

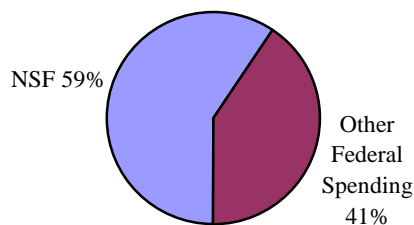
GEO Subactivity Funding
(Dollars in Millions)



RELEVANCE

GEO provides about 59 percent of the total federal funding for university-based, basic research in the geosciences. In addition to playing a critical role in addressing the Nation's need to understand, predict, and respond to environmental events and changes, GEO also helps to determine the best use of Earth's resources. Fundamental research in the geosciences advances scientific knowledge of resources such as fresh water, energy, minerals, and biological diversity, leading to improved future quality of life. GEO

Federal Support for Basic Research in Geosciences at Academic Institutions



investments include many environmental studies coordinated through the U.S. Climate Change Science Program. GEO supports many national and global observational facilities and other research infrastructure for land, ocean, and atmospheric processes.

GEO supports basic research that advances the frontiers of knowledge and drives technological innovation while improving our understanding of the many processes that affect the global environment. These processes include the role of the atmosphere and oceans in climate, the planetary water cycle, and ocean acidification. Support is provided for interdisciplinary studies that contribute directly to national research priorities: hydrologic systems, biogeochemical dynamics, ecological systems and dynamics, solid earth processes, and solar influences on the Earth system. Lives are saved and property is preserved through better prediction and understanding of natural environmental hazards such as earthquakes, tornados, hurricanes, tsunamis, drought, and solar storms. Basic research supported by GEO enables preparation for and subsequent mitigation of or adaptation to the effects of these and other disruptive natural events. Associated with these studies is the need for databases and cyberinfrastructure to provide the scientific community with the resources to assemble and utilize data and information efficiently and effectively, consistent with the Administration's priorities for research and development.

GEO supports research and education in a variety of areas that are consistent with the American Competitiveness Initiative. Many fields within the geosciences focus on physics in the environment – solar-terrestrial interactions and the complex interplay of forces in the Earth's core that creates the Earth's magnetic field, for example – and other areas such as integrated water cycle science and studies of climate change are of tremendous relevance with potentially huge economic benefits. Further, activities supported by GEO are well-aligned with the Administration's research and development priorities, including investments in high-end computing, improving our ability to understand and respond to global environmental issues, and improving quality of life. Finally, geoscience research directly contributes to NSF's priority of fostering research that improves our ability to live sustainably on Earth.

GEO will coordinate with other federal agencies and the science community to implement both near-term and longer-term goals as articulated in the Ocean Research Priorities Plan. In particular, near-term interagency studies will emphasize forecasting the responses of coastal ecosystems to persistent forcing and extreme events and the development of new marine ecosystem sensors for measurement of biological, physical, and chemical properties of the ocean. Also important will be comparative analysis of marine ecosystem organization and a robust assessment of the variability of the Atlantic meridional overturning circulation and its implications for rapid climate change.

Two critical areas receiving increased emphasis in FY 2009 are the NSF-wide activities Dynamics of Water Processes in the Environment and Cyber-enabled Discovery and Innovation (CDI). Science has advanced to the point that it is now possible to examine terrestrial water as a dynamic system rather than as the aggregate of discrete components. In FY 2009, the focus of GEO's investment will be to define frontier research opportunities, delineate NSF's leadership role in this area and advance activities in foundational water systems research. This investment will create the scientific basis for analytical models that can anticipate fresh water needs and availability under a variety of human-forced scenarios and as mediated by climate change. GEO's investment in CDI will focus on the development of the next generation of computationally-based discovery concepts and tools to deal with data-rich and interacting systems.

Summary of Major Changes by Division (Dollars in Millions)

FY 2008 Estimate, GEO \$752.66

Atmospheric Sciences (ATM) +31.28

Increased support will augment research to understand and predict environmental extreme events and to understand the effects of biogeochemical cycles. Increased support will also be provided for advanced cyberinfrastructure and numerical models; and to increase participation in key interagency such as the US Climate Change Science Program, the U.S. Weather Research Program and the National Space Weather Program. Support for atmospheric observing facilities and the National Center for Atmospheric Research will increase to enable expansion of activities related to climate modeling and provision of world-class ground, airborne, and space-borne observational facilities and services.

Earth Sciences (EAR) +\$21.65

Increased funding is focused on operational and scientific support of the EarthScope facility. Research support in EAR will also increase, with emphasis on support for theoretical research, including the biological geosciences, the hydrologic sciences and the study of natural hazards, such as earthquakes and volcanic eruptions. The final year of construction funding for EarthScope was appropriated through the Major Research Equipment and Facilities Construction (MREFC) account in FY 2007, although construction activities will continue through FY 2008.

Innovative & Collaborative Education and Research (ICER) +\$0.00

In FY 2009, support for international collaborative activities and other cross-directorate programs will remain level, enabling continued international collaborations, maintenance of crosscutting diversity and education programs, and programs focused on integrated earth systems research.

Ocean Sciences (OCE) +\$43.08

Areas receiving increased funding support include developmental activities related to the Ocean Observatories Initiative, operation of the Academic Research Fleet, and operational support for the Integrated Ocean Drilling Program. Increased support will also target the near-term research priorities of the Ocean Research Priorities Plan, emerging trends in the biogeochemical cycles, and paleoperspectives on climate change.

Subtotal, Changes +\$96.01

FY 2009 Request, GEO \$848.67

Summary of Major Changes in Directorate-wide Investments (Dollars in Millions)

FY 2008 Estimate, GEO \$752.66

Discovery +\$46.40

Cyber-enabled Discovery and Innovation (+\$3.42 million).

Investment in CDI seeks to infuse computational thinking into all areas of the geosciences, bringing computational capabilities into the traditional experimentation-observation-analysis-

theory research paradigm. GEO's investment in CDI will focus on the development of the next generation of computationally-based discovery concepts and tools to deal with data-rich and interacting systems.

Dynamics of Water Processes in Earth's Environment (+\$5.26 million).

Initial GEO funding of funding of \$5.26 million in FY 2009 will focus on defining frontier research opportunities, delineating NSF's leadership role in this area and advancing activities in foundational water systems research, establishing open access data systems, and mining data for essential scientific information.

Ocean Research Priorities Plan (+\$12.0 million).

Responding to the Ocean Research Priorities Plan (ORPP), GEO will support highly meritorious proposals addressing both the near-term and long-term priorities articulated in the ORPP.

Disciplinary and Interdisciplinary Research (+\$24.77 million).

GEO investments in fundamental research will continue to advance the frontiers of knowledge and discovery by working across traditional boundaries and encouraging multidisciplinary, transformative, and high-impact research. Contributing to American technical innovation and scientific leadership, these investments directly address government-wide research and development priorities, particularly those related to innovation; understanding global and regional environmental issues, such as adaptation and mitigation to climate change; natural disasters; and improving the future quality of life.

Centers (-\$50,000).

In FY 2009, several changes to centers support are planned. Beginning in FY 2009, GEO will partially support, at \$250,000, a center on nano-related environment, safety, and health. Also, support for a Science and Technology Center (STC) started in FY 2000 will ramp down as planned toward sunset in FY 2009.

CAREER (+\$1.0 million).

Support for NSF's premier award for early career investigators will increase by \$1.0 million.

Learning

+\$0.48

Integrative Graduate Education and Research Traineeships (IGERT) (+\$80,000).

An increase of \$80,000 to a total of \$3.47 million will enable the support of additional participants in this important cross-Foundation program.

Research Experiences for Undergraduates (+\$400,000).

Support for both REU supplements and sites will be augmented, enabling the support of approximately 50 additional student participants.

Research Infrastructure

+\$46.33

Academic Research Fleet (+\$13.30 million).

GEO is the primary supporter of operations of the national Academic Research Fleet. An increase of \$14.8 million, to a total of \$87.96 million, will augment support of ship operations and provide a number of enhancements to the academic fleet.

Within this amount, an increase of \$6.80 million to a total of 72.96 million will enable NSF-supported researchers to conduct research in the world's oceans. FY 2009 is planned as the start of a series of up to three Regional-class Research Vessel acquisitions (\$10.0 million, an increase of \$8.50 million over the FY 2008 Estimate) to move beyond the design phase and begin construction of ships to replace aging and less capable ships. Replacement Human Occupied Vehicle (RHOV) construction continues at a level of \$1.0 million.

EarthScope Operation (+\$8.68 million).

Operational support of the EarthScope facility funded through GEO is \$26.29 million in FY 2009, an increase of \$8.68 million over the FY 2008 Estimate, enabling operation of the completed facility. The final year of construction funding for EarthScope was appropriated through the MREFC account in FY 2007, although construction activities will continue through FY 2008.

Incorporated Research Institutions for Seismology (IRIS) Operation (+\$450,000).

Operational support of the IRIS facility will total \$12.2 million, a \$450,000 increase over the FY 2008 Estimate. This increase will enable the repair, and upgrade of seismic stations and instrument replacements.

Ocean Drilling Activities (+\$8.48 million).

The Integrated Ocean Drilling Program (IODP), including operation of the Scientific Ocean Drilling Vessel (SODV) acquired and outfitted with support from the MREFC account, will increase overall by \$8.48 million to a total of \$47.74 million. FY 2009 represents the first fiscal year the refurbished drillship will be fully available to the program after extensive shipyard work.

Ocean Observatories (+\$1.5 million).

Support for activities to prepare for the Ocean Observatories Initiative, one of GEO's contributions to the Global Earth Observation Systems of Systems (GEOSS) will increase to enable continued planning.

National Center for Atmospheric Research (NCAR) (+\$9.0 million).

NCAR is a Federally Funded Research and Development Center (FFRDC) supported by NSF and other federal agencies to provide facilities and support for a wide range of studies in the atmospheric and related sciences. In FY 2009, GEO support for NCAR will increase by \$9.0 million, to a total of \$95.42 million to: accelerate efforts in provide robust, accessible, and innovative information services and tools to the community; enhance NCAR's ability to provide to researchers world-class ground, airborne, and space-borne observational facilities and services; increase our understanding of societal resilience to weather, climate, and other atmospheric hazards; and increase efforts to cultivate a scientifically literate and engaged citizenry and a diverse and creative workforce.

Research Resources (+\$4.82 million).

Support for community instruments and databases, including the University Navstar Consortium (UNAVCO), a number of radar facilities to study processes in the upper atmosphere, and many small instruments supported for research community use will increase by \$4.82 million to a total of \$64.16 million.

Other Research Infrastructure (+\$100,000).

Support for the National Astronomy and Ionosphere Center (NAIC) will be augmented slightly to enable Geoscience activities at this facility to continue at a comparable level to FY 2008.

Stewardship +\$2.80

A number of activities are funded directly from NSF's programs to advance NSF's Stewardship goal. These include Intergovernmental Personnel Act appointments, NSF-wide studies and evaluations, and mission-related information technology investments. As is discussed further in the Stewardship chapter of this Request, in FY 2009 NSF has realigned IT investments to tie mission-related activities more directly to NSF's programs.

Subtotal, Changes +\$97.05

FY 2009 Request, GEO..... \$848.67

GEO Facilities Funding

(Dollars in Millions)

Facilities	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over	
				FY 2008 Estimate Amount	Percent
Academic Research Fleet	\$87.94	\$70.66	\$83.96	\$13.30	18.8%
<i>Regional Research Vessel</i>	1.57	1.50	10.00	8.50	566.7%
<i>RHOV Construction (R/V Alvin Replacement)</i>	9.05	1.00	1.00	-	-
<i>R/V Langseth Construction (R/V Ewing Replacement)</i>	0.69	2.00	-	-2.00	-100.0%
<i>Ship Operation and Upgrade</i>	76.63	66.16	72.96	6.80	10.3%
EarthScope: USArray, SAFOD, PBO	11.63	17.61	26.29	8.68	49.3%
Incorporated Research Institutions for Seismology	11.77	11.75	12.20	0.45	3.8%
Integrated Ocean Drilling Program (IODP)	34.71	39.26	47.74	8.48	21.6%
Nanofabrication (NNIN)	0.50	0.50	0.50	-	-
Ocean Observatories	6.49	9.00	10.50	1.50	16.7%
NCAR	85.12	86.42	95.42	9.00	10.4%
NAIC	-	1.70	1.80	0.10	5.9%
Total, GEO	\$238.15	\$236.90	\$278.41	\$41.51	17.5%

Totals may not add due to rounding.

NSF-WIDE INVESTMENTS

In FY 2009, the Directorate for Geosciences will support research and education efforts related to broad, Foundation-wide investments in a number of areas including the Administration's interagency R&D priorities.

GEO Funding for NSF-Wide Investments

(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change Over FY 2008 Estimate	
				FY 2008 Amount	Percent
Biocomplexity in the Environment	\$26.1	-	-	-	n/a
Climate Change Science Program	157.7	157.7	164.7	7.0	4.4%
Cyber-enabled Discovery & Innovation	-	1.0	4.4	3.4	342.0%
Cyberinfrastructure	75.0	75.0	80.0	5.0	6.7%
Dynamics of Water Processes in the Environment	-	-	5.3	5.3	n/a
Human & Social Dynamics	1.4	1.4	-	-1.4	-100.0%
International Polar Year	5.7	5.0	-	-5.0	-100.0%
Mathematical Sciences	5.8	-	-	-	n/a
National Nanotechnology Initiative	9.7	9.7	6.3	-3.3	-34.4%
Networking & Information Technology R&D	14.6	15.6	19.0	3.4	22.0%

Biocomplexity in the Environment: With the conclusion of this priority area in FY 2007, key components of investment in Biocomplexity in the Environment will be transferred to core programs for continued support, with selected aspects such as studies of biogeochemical cycles being revitalized.

Climate Change Science Program (CCSP): GEO leads NSF efforts in the interagency CCSP to enhance understanding of the dynamics among natural and human systems, generate the knowledge needed to preserve, manage, and enhance the environment, as well as to support national and international policy-making activities. Directly contributing to the Administration’s R&D priorities, specific activities include programs focused on understanding past climate variability, elucidating how carbon and nitrogen cycle through the earth, atmosphere, and oceans, and efforts to develop and refine computational models of Earth system processes. In FY 2009, increased emphasis will be placed on understanding the Earth’s water cycle and on climate-driven aspects of disruptive environmental events, such as hurricanes and severe storms.

Cyber-enabled Discovery and Innovation: Investments in CDI seek to infuse computational thinking into all areas of the geosciences, bringing computational capabilities into the traditional experimentation-observation-analysis-theory research paradigm. GEO’s investment in CDI will focus on the development of the next generation of computationally-based discovery concepts and tools to deal with data-rich and interacting systems.

Cyberinfrastructure (CI): GEO cyberinfrastructure investment supports the development of IT-based research infrastructure for disciplines across the geosciences. One flagship activity is the Climate Simulation Laboratory at NCAR, located in Boulder, CO, which serves a broad community of researchers utilizing advanced computational techniques to model atmospheric processes ranging from projections of future climate to forecasting hurricane intensity and landfall.

Dynamics of Water Processes in the Environment: Science has advanced to the point that it is now possible to examine terrestrial water as a dynamic system rather than as the aggregate of discrete components. In FY 2009, the focus of this investment will be to define frontier research opportunities, delineate NSF’s leadership role in this area and advance activities in foundational water systems research. This investment will create the scientific basis for analytical models that can anticipate fresh water needs and availability under a variety of human-forced scenarios and as mediated by climate change.

Human and Social Dynamics (HSD): With the conclusion of this priority area in FY 2008, the collaboration between social scientists and geoscientists will continue informally through ongoing research programs.

International Polar Year (IPY): With the conclusion of IPY in March 2009, components of the investment will be transferred to core programs for continued support.

Mathematical Sciences: With the conclusion of this priority area in FY 2007, the collaboration between mathematicians and geoscientists will continue informally through ongoing research programs.

National Nanotechnology Initiative (NNI): Nanotechnology is recognized as one of the current frontiers of innovation, and is specifically linked to the ACI. Contributing to NNI, GEO will support studies of natural nanoscale processes in the environment and utilize nanoscale phenomena as catalysts for environmental remediation.

Networking and Information Technology Research and Development (NITRD): Investments in this area advance the state-of-the-art in computing and information technology, and support the development of a worldclass computing workforce and a broader IT-savvy workforce. Within NITRD, an area which explicitly supports the Administration's agency-wide R&D priorities, GEO focuses on the development and enhancement of computational modeling capacity and capability.

QUALITY

GEO maximizes the quality of the R&D it supports through the use of a competitive, merit-based review process. The share of basic and applied research funds that were allocated to projects that undergo merit review was 77 percent in FY 2007, the last year for which complete data exist. OMB's definition of competitive, merit-based review, however, 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. If included, the merit-reviewed share of GEO funding would rise to 88 percent.

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. In FY 2009, GEO will convene COVs for the University Corporation for Atmospheric Research (UCAR) and the Lower Atmospheric Facilities Oversight Section of the ATM Division, the Ocean Section of the OCE Division, and the Marine Geosciences Section of the OCE Division. In FY 2008, GEO will convene COVs for the Upper Atmospheric Facilities Section of the ATM Division, the Surface Earth Processes Section and the Deep Earth Processes Section in the EAR Division, and the Integrative Projects Section in the OCE Division. COVs were convened for the Lower Atmospheric Research Section of the ATM Division, the Instrumentation and Facilities Program in the EAR Division and GEO's Education and Diversity Programs in FY 2007.

The Directorate 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. The 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 broad range of

academic institutions and industry; broad geographic representation; and balanced representation of women and under-represented minorities.

PERFORMANCE

The FY 2009 Budget Request is aligned to reflect funding levels associated with the Foundation's four strategic outcome goals stated in the FY 2006-2011 Strategic Plan. These goals provide an overarching framework for progress in fundamental research and education and facilitate budget and performance integration.

Geosciences By Strategic Outcome Goal (Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate	
				Amount	Percent
Discovery	\$404.91	\$419.00	\$471.30	\$52.30	12.5%
Learning	33.18	30.26	30.74	0.48	1.6%
Research Infrastructure	300.00	295.65	336.07	40.42	13.7%
Stewardship	7.75	7.75	10.55	2.80	36.1%
Total, GEO	\$745.84	\$752.66	\$848.67	\$96.01	12.8%

Totals may not add due to rounding.

GEO will continue its commitment to education, training, and increasing diversity in FY 2009. The FY 2009 Request will permit an increase in average award size and allow GEO to continue to focus on multidisciplinary research activities, inter-agency partnerships, and international activities with special attention given to broadening participation at all levels. In addition, the sustaining of existing infrastructure and the development of new infrastructure remain priorities, with ongoing support for the acquisition of new regional research vessels and increased support for ship upgrades, the Ocean Drilling Activities program and the operation of the EarthScope facility being constructed through the MREFC account.

Recent Research Highlights

► **Scientists Explain Source of Tiny Tremors Emanating from Fault Zones:**

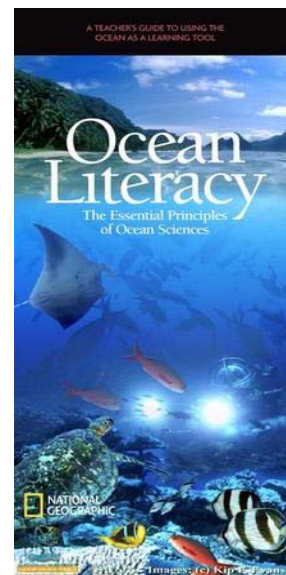
Tiny earthquakes, discovered in fault zones from California to Japan, may foreshadow catastrophic events. NSF-supported seismologists say these findings may be useful in understanding potentially destructive mega-quakes of magnitude 8 or higher. They found that non-volcanic tremors are often accompanied by low-frequency earthquakes – small quakes of magnitude 1 or 2. Recent studies suggest that giant quakes are preceded by a series of much deeper events called slow (or silent) earthquakes, which displace the ground without shaking it. A slow earthquake can last days, months, or years without being felt at the surface. The insight may open new avenues of research for predicting earthquake hazards by using low-frequency earthquakes as indicators. It could lead to an improved ability to forecast a major earthquake. (EAR)



Entire buildings tilt because of ground failure after the Niigata, Japan, earthquake. *Credit: NGDC.*

► **Developing Ocean Literacy:** The often devastating consequences of hurricanes and tsunamis, and the even larger-scale consequences of global climate change, ocean acidification, and the collapse of commercial fisheries, illustrate the powerful role that ocean processes play in shaping the human condition. Preventing or mitigating these consequences requires that ocean scientists, educators, and policy makers work together so that informed choices are made for the common good.

The Centers for Ocean Sciences Education Excellence (COSEEs) have been instrumental in promoting the development of ocean literacy concepts at a national scale. In June 2006, NSF co-sponsored the Conference on Ocean Literacy which brought together representatives from federal agencies, experts in formal and informal education, non-governmental organizations, and industry representatives to lay the groundwork for developing a national strategy for an ocean-literate society. The recommendations from the conference include revamping curricular standards, improving linkages between the research communities, educators, and government agencies, and fostering regional and national networks. Together, they represent a major advance in meeting the challenge of increasing public understanding of ocean processes. (OCE)



The Ocean Literacy Initiative.
Credit: Copyright Kip F Evans.



Landsat satellite image of the Salton Sea, Coachella Valley and the San Andreas fault in California. Credit: Yuri Fialko UCSD/SIO

► **Study Shows Southern San Andreas may be Ready for a Major Earthquake:** Yuri Fialko at the University of California, San Diego Scripps Institute of Oceanography was funded by NSF to explore the Earth's deformation in southern California, using satellite images, GPS and seismic measurements.

This research has substantially improved description and understanding of the strain building along major plate boundary faults, the southern San Andreas Fault and the San Jacinto Fault. Fialko calculated that over the last 300 years the San Andreas Fault has accumulated 6 to 8 meters of slip deficit (between 20 and 26 feet), which is close to or in excess of the maximum slip deficit ever documented for the fault. The San Jacinto Fault is straining at rates higher than other estimates, at 19-21 millimeters per year (between .75 and .83 inches per year).

In addition, a prominent feature of the strain accumulation that has not been previously recognized is that the eastern side of the faults are moving faster than the western side. The results also imply that the southern San Andreas Fault is in the late phase of seismic loading and may be primed for a significant earthquake. The researcher collaborated with the Scripps Institution of Oceanography Visualization Center to provide online, visually compelling illustrations of these recent results to a broader audience. (EAR)

► **Scientists Track Impact of Asian Dust and Pollution on Clouds, Climate Change:** Scientists are using one of the nation's newest and most capable research aircraft, HIAPER, a modified Gulfstream-V aircraft, for a far-reaching field project to study plumes of airborne dust and pollutants that originate in Asia and journey to North America. The plumes are among the largest such events on Earth, so great in scope that scientists believe they might affect clouds and weather across thousands of miles while interacting with the sun's radiation and playing a role in global climate. Known as PACDEX (Pacific Dust Experiment), the project will be led by scientists at the NSF-supported National Center for Atmospheric Research and the Scripps Institution of Oceanography. PACDEX will help scientists refine computer models of greenhouse gas emissions and improve forecasts of future climate change. (ATM)



Plumes from airborne dust and pollutants will be studied during the Pacific Dust Experiment. Credit: NCAR..



Landing of Codfish in the Gulf of Maine. Credit: Massachusetts Division of Marine Fisheries.

► **Biodiversity Loss in the Oceans Impacts Human Resources:** Marine ecosystems around the world are being impacted by multiple environmental and human pressures that result in the loss of populations and species. The effect is commonly referred to as a decrease in biodiversity. While the outcomes of these losses are difficult to understand and predict, recent research funded by NSF's Biological Oceanography Program and conducted by Emmett Duffy from the Virginia Institute of Marine Sciences, Fiorenza Micheli of Stanford University, and John Stachowicz at the University of California, Davis, and analyzed at the NSF-supported National Center for Ecological Analysis and Synthesis (NCEAS), describes both the gravity of the changes and mechanisms to remediate the current trajectories of biodiversity loss (Worm et al., 2006 Science 314: 787-790).

By conducting a large scale analysis of published data from a wide variety of coastal and oceanic ecosystems, the authors were able to discern important long-term ecological patterns. The analysis shows that increased diversity of primary producers (phytoplankton, seagrasses, etc.) and primary consumers enhanced all ecosystem processes examined, such as nutrient

cycling, growth, transfer of energy through the food web, and the ability to withstand repeated disturbances such as storms or hurricanes.

Their research also revealed that biodiversity losses contribute to significant declines in fishery resources and areas used as nursery habitats for fishes. Globally, commercial fish populations have been on a long downward trend, and their ability to recover is dramatically degraded by declining biodiversity. Significantly, however, the research showed that when marine ecosystems are protected through restoration efforts or the establishment of marine protected areas (MPAs), the yield of fisheries increases. By maintaining species diversity in a wide variety of marine ecosystems, many key processes that humans

have come to rely on (such as fisheries yields and pollution control) may be maintained and improved with long-term economic benefits. (OCE)

► **Northwest Atlantic Ocean Ecosystems Experiencing Large Climate-Related Changes:**

Ecosystems along the continental shelf waters of the Northwest Atlantic Ocean are experiencing large, rapid changes. While some scientists have pointed to the decline of cod from overfishing as the main reason for the shifting ecosystems, researchers emphasize climate change is also playing a big role. A majority of scientists believe humans are warming the planet by burning fossil fuels and changing land surfaces, with early signs of this warming now appearing in the Arctic. Since the late 1980s, scientists have observed pulses of fresh water from increased precipitation and melting of ice on land and sea in the Arctic. This fresh water flows into the North Atlantic Ocean, making the water less salty. At the same time, climate-driven shifts in Arctic wind patterns have redirected ocean currents. The combination of these processes has led to a freshening of the seawater along the North Atlantic shelf which in turn has impacted the seasonal cycles of phytoplankton (tiny floating plants), zooplankton (tiny animals like copepods) and fish populations that live near the surface. (OCE)



The influx of fresh water from Arctic climate change is impacting seasonal fisheries and plankton. *Credit: JupiterImages.*



COSMIC launch from Vandenberg Air Force Base in California at 6:40 p.m. PDT (9:40 p.m. EDT) on Friday, April 14, 2006. *Credit: Photo courtesy of Orbital Sciences Corporation.*

► **Revolutionary Satellite System Boosts Accuracy of Weather and Climate Predictions:**

Preliminary findings from a novel satellite system launched earlier this year show that the system can increase the accuracy of forecasts of hurricane behavior, significantly improve long-range weather forecasts, and monitor climate change with unprecedented accuracy. The set of six microsattellites, launched in April 2006, is probing the atmosphere in ways that have been impossible with previous observing systems. The system, Constellation Observing System for Meteorology, Ionosphere and Climate (COSMIC), is based on a design provided by the University Corporation for Atmospheric Research (UCAR).

COSMIC works by tracking tiny changes in the speed of GPS radio signals. Using these data, scientists can now produce vertical profiles of temperature and water vapor at more than 1,000 points over Earth each day, sampling the troposphere (the atmosphere's "weather layer," closest to Earth's surface) and the stratosphere. By next year, some 2,500 profiles will be produced daily. Higher up, the system measures electron density in the ionosphere, an important observation for space-weather analysis and forecasting.

In a test at the European Centre for Medium-Range Weather Forecasts, scientists added COSMIC data to the other weather observations used to kick-start computer forecast models. With the help of COSMIC data, stratospheric temperature forecasts over the Northern Hemisphere improved significantly. Predictions of hurricanes and typhoons should also benefit from COSMIC. A test involving one of the main U.S. forecast models found that the model was able to predict the birth of Hurricane Ernesto in 2006 two days in advance with COSMIC data. Without the data, the model was unable to predict Ernesto's formation. Tests in Taiwan involving Tropical Storm Bilis and

other cyclones showed that COSMIC data can reduce errors in track prediction. Generating thousands of profiles each day, COSMIC data will also help scientists observe the density of high-altitude electrons associated with damaging solar storms. Until now, altitudes of peak electron density have been difficult to study and predict because forecast models have had limited data on the vertical distribution of electrons.

The \$100 million COSMIC network is the product of an agreement between the American Institute in Taiwan and the Taipei Economic and Cultural Representative Office in the United States. COSMIC is known as FORMOSAT-3 in Taiwan. U.S. support for COSMIC is provided by the National Science Foundation, NASA, the National Oceanic and Atmospheric Administration, and the Office of Naval Research. The Jet Propulsion Laboratory developed the GPS receivers used in COSMIC. (EAR)



► **Science Quest: Engaging At-Risk Students:** Scientists at the University of South Carolina are leading a program designed to increase minority student participation in the geosciences using an after school program called Science Quest. In this program, University of South Carolina graduate students in science (team leaders) work with three to five 6th grade "at-risk" students in exploring a geoscience-related topic. Teams meet once a week for 1.5 hours over a period of 10-12 weeks at two parks in poor neighborhoods. Secondary goals are to expose graduate students to outreach activities, develop hands-on activities involving their research, and use geoscience equipment in middle school classrooms. (EAR)

Graduate student and middle school children working on an experiment. *Credit: Dee Albritton (Fast Forward Technology Center) and Dr. Claudia Benitez-Nelson (University of South Carolina).*

Other Performance Indicators

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

Number of People Involved in GEO Activities

	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate
Senior Researchers	4,188	4,200	4,700
Other Professionals	2,934	3,000	3,400
Postdoctorates	617	600	700
Graduate Students	2,416	2,400	2,700
Undergraduate Students	1,672	1,700	1,900
Total Number of People	11,827	11,900	13,400

GEO Funding Profile

	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate
Statistics for Competitive Awards:			
Number	1,347	1,400	1,600
Funding Rate	31%	31%	31%
Statistics for Research Grants:			
Number of Research Grants	1,037	1,100	1,250
Funding Rate	27%	27%	28%
Median Annualized Award Size	\$119,713	\$120,000	\$125,000
Average Annualized Award Size	\$153,922	\$155,000	\$160,000
Average Award Duration, in years	3	3	3

ATMOSPHERIC SCIENCES

\$260,580,000

The FY 2009 Request for the Division of Atmospheric Sciences (ATM) is \$260.58 million, an increase of \$31.28 million, or 13.6 percent, over the FY 2008 Estimate of \$228.7 million.

Atmospheric Sciences Funding
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over	
				FY 2008 Estimate Amount	Percent
Atmospheric Sciences Research Support	\$142.32	\$142.88	\$165.16	\$22.28	15.6%
National Center for Atmospheric Research	85.12	86.42	95.42	9.00	10.4%
Atmospheric Sciences	\$227.44	\$229.30	\$260.58	\$31.28	13.6%
Major Components					
Research and Education Grants	104.93	105.38	125.16	19.78	18.8%
Centers Programs					
Center for Integrated Space Weather Modeling	4.00	4.00	4.00	-	-
Center for Atmospheric Process Modeling	4.00	4.00	4.00	-	-
Facilities					
National Center for Atmospheric Research (NCAR)	85.12	86.42	95.42	9.00	10.4%
Research Resources and Infrastructure	29.39	29.50	32.00	2.50	8.5%

Totals may not add due to rounding.

About ATM:

The North American continent is subject to some of the world’s most severe weather. As well as the impacts of winter Pacific storms, tropical storms over the Atlantic Ocean, Caribbean Sea, or Gulf of Mexico can develop into fierce hurricanes that pound coastal regions, spawning tornadoes and producing torrential rains and floods, and resulting in large numbers of fatalities and billions of dollars in damage to property. In the upper reaches of the Earth’s atmosphere, huge solar storms can damage satellites, disrupt communication and navigation systems, and cause widespread failures in the electrical power grid. The human impacts of urban pollution and extreme weather can be severe and costly. In order to improve our ability to predict and mitigate these events, we need to further our understanding of the physics, chemistry, and dynamics of the Earth’s atmosphere, from the Earth’s surface to the sun, on timescales ranging from minutes to millennia. We need to better understand the underlying trends, the impact of man-made changes, the complex interactions between systems, and the coupling among the atmosphere, the biosphere, and the oceans. ATM supports such research through the provision of large, complex facilities, community modeling projects, cyberinfrastructure, and individual research grants, providing about 60 percent of the total federal support for academic atmospheric research.

ATM provides support for: 1) basic science projects and 2) the acquisition, maintenance, and operation of observational and cyberinfrastructure facilities and services that enable modern day atmospheric science research activities.

For the science activities supported by ATM, a variety of modes of support are used. Although the majority of this support is through the traditional “individual investigator” merit-reviewed, multi-year grants, ATM also supports small scale, limited-duration exploratory research projects; collaborative or multi-investigator group projects focusing on a particular project, subject, or activity; large center or

center-like projects; and funding for the research conducted by NSF's National Center for Atmospheric Research (NCAR), which extends and enhances research at universities.

Facility funding is provided through cooperative agreements to NCAR and several other institutions to acquire, maintain, and operate specific observational and cyberinfrastructure facilities that support the research and educational activities of NSF-sponsored projects, scientists, and students.

ATM supports a diverse portfolio of research, education, and infrastructure activities. Approximately 46 percent of the annual budget of ATM is used to support individuals and small groups of researchers, with approximately 17 percent of the total division budget being available to support new research grants.

ATM priorities for FY 2009:

- Natural Hazards: Building on years of research to understand and predict weather and space weather phenomena, these research activities will be augmented to better understand and predict extreme events such as cyclone formation and life cycle;
- Biogeochemical Cycles: Research in this area includes an emphasis on understanding the sources, sinks, and processes which control the atmospheric abundance and distribution of carbon, water, and other environmentally important elements;
- Environmental Modeling: Support for new data assimilation and innovative mathematical and statistical techniques will improve predictions of fundamental space, atmospheric, and Earth system processes;
- Cyberinfrastructure and Numerical Models: Improvements in this area will allow new discoveries, greater access to atmospheric data, and improved understanding of the atmospheric environment; and
- Interagency and International Programs: ATM will continue support of these programs, including the Climate Change Science Program, the U.S. Weather Research Program, the National Space Weather Program and cooperative international science programs.
- ATM will accelerate investment in NCAR to significantly increase progress towards understanding the Earth system and improve research infrastructure capabilities available to the atmospheric sciences community.

Changes from FY 2008:

- The increase in FY 2009 will permit targeted key areas of research which were flat funded in FY 2008 to move forward. The increased support for research and education grants and centers by \$17.58 million, to a total of \$116.83 million, will also permit limited growth in the disciplinary programs, viz:
 - an increase of \$4.0 million in research on natural hazards (i.e. severe weather and space weather);
 - an increase of \$4.0 million for cyberinfrastructure investments; and
 - an increase of \$9.58 million in other disciplinary programs.

Limited additional funds in FY 2008 prevented efforts to enhance the ATM-supported facilities. With an FY 2009 increase of \$14.30 million to a total of \$135.75, ATM will accelerate efforts to provide the community with robust, accessible, and world-class ground, airborne, and space-borne observational facilities and services. This increase includes:

- an increase of \$9.05 million for NCAR; and
- an increase of \$5.25 million for operations of AMISR and other atmospheric research facilities.

Additional information on major ATM-supported facilities is available in the Facilities chapter.

EARTH SCIENCES

\$177,730,000

The FY 2009 Request for the Division of Earth Sciences (EAR) is \$177.73 million, an increase of \$21.65 million, or 13.9 percent, over the FY 2008 Estimate of \$156.08 million.

Earth Sciences Funding

(Dollars in Millions)

			Change over		
	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	FY 2008 Estimate Amount	Percent
Earth Science Project Support	117.66	120.90	139.57	18.67	15.4%
Instrumentation and Facilities	35.17	35.18	38.16	2.98	8.5%
Earth Sciences	\$152.83	\$156.08	\$177.73	\$21.65	13.9%
Major Components:					
Research and Education Grants	99.55	97.68	107.93	10.25	10.5%
Centers Programs					
Sustainability of Semi-Arid Hydrology and Riparian Areas	3.29	2.96	2.96	-	-
National Center for Earth-Surface Dynamics	3.60	3.60	3.60	-	-
Facilities					
Incorporated Research Institutions for Seismology (IRIS)	11.77	11.75	12.20	0.45	3.8%
EarthScope Operations	11.63	17.61	26.29	8.68	49.3%
Other Earth Sciences Infrastructure	23.00	22.48	24.75	2.27	10.1%

Totals may not add due to rounding.

About EAR:

The Earth functions as a complex system that affects every aspect of our daily lives. Earthquakes and related tsunamis periodically result in devastating loss of property and lives, and erupting volcanoes are fed by tectonic processes deep in the earth and may create great societal disruption. The Earth's liquid-core-generated magnetic field is undergoing rapid change that may be related to mantle convection processes. Our energy is largely provided by fossil fuels discovered in the subsurface and pumped or mined. The energy industry pumps liquid carbon dioxide into geological formations both as means of enhancing oil recovery and sequestration of carbon from the fossil fuel-dependent power generation process. The clean water we require to sustain life is made available through the hydrologic cycle. Clues to the climate change process lie in buried sediments and rocks that can be analyzed from drill cores. Soil forming and modification processes directly impact agriculture. EAR supports the study of these and many other Earth processes by providing funds for research and education, instrumentation, cyberinfrastructure, and shared-use facilities.

EAR supports a diverse portfolio of research, education, and infrastructure activities. Approximately 65 percent of the annual budget of EAR is used to support individuals and small groups of researchers, with approximately 31 percent of the total division budget being available to support new research grants.

Earth science is moving into a new era as we deploy an unprecedented array of instrumentation to image the planet's interior, sense the tectonic motions of the surface (for example, with the Global Seismographic Network and NSF's EarthScope project), and establish observatories for study of the Earth's environmental systems. Massive amounts of data generated by these observations require a revolution in hardware and software capability. Geoinformatics is the collaboration between geoscientists and computer scientists to utilize these data and solve complex scientific problems. EAR has enhanced

its support to link available data sets, standardize documentation, and provide easy-to-use access tools and computer modeling and analysis codes for scientists and educators alike. Projects currently supported include:

- Consortia of universities, such as the Incorporated Research Institutions for Seismology (IRIS), UNAVCO, Inc. and WInSAR, maintain highly sophisticated seismic, geodetic, and satellite radar data that are heavily used by the research and hazards community. For example, the seismic data provided by the IRIS Global Seismographic Network gave emergency personnel the first indication of the location and severe damage potential of the great Sumatra earthquake and tsunami of December 2004.
- EAR is supporting the development of a hydrologic information system that will provide seamless access to a variety of datasets such as the National Water Information System, the Ameriflux tower network, and the National Climatic Data Center. These systems are increasingly vital for decisions affecting water management in arid regions, flood mitigation, and groundwater pollution containment.
- Geoinformatics-supported projects are linking data sets bearing on sedimentary sequences and geologic time. This will greatly improve our understanding of the Earth's surface environments and climate changes in deep time.
- The Southern California Earthquake Center (SCEC) has been utilizing computational facilities at the University of California San Diego Supercomputer Center to build complex models of the crust of southern California and its response to great earthquakes on local faults. Their results are providing significant input to disaster preparedness and a better understanding of fundamental earthquake processes.
- The Computational Infrastructure for Geodynamics (CIG) project, headquartered at the California Institute of Technology, but with participation of at least 24 other research institutions, will focus on developing advanced software to enable individual Earth scientists to produce more realistic simulations in fields such as seismology, plate tectonics, volcanism, and geomagnetism.

EAR priorities for FY 2009:

- EarthScope Operations and Science Support: The new EarthScope facility will begin full operations and maintenance enabling new science at the intersection of several subfields within the earth sciences. Construction activities will conclude in FY 2008, and full operations begin in FY 2009. Supporting the operation of the facility and the science it enables continues to be a high priority for EAR. Additional information can be found in the Facilities chapter.
- Maintaining a strong, flexible program of research and education grants to create new ideas and technologies and attract and train students is the primary focus in stewardship of the EAR portfolio. Emphasis will be given to increasing the support for theoretical research, including the biological geosciences, the hydrologic sciences and the study of natural hazards, such as earthquakes and volcanic eruptions. The key element across the EAR portfolio is expanding the science community's capability for computationally challenging global-scale research, such as dynamic modeling of Earth system processes, and managing and integrating very large data sets.

Changes from FY 2008:

- In FY 2008, EarthScope operations and maintenance could only be supported at \$17.61 million rather than \$21.61 million as requested. The FY 2009 Request addresses this shortfall by increasing the level to \$26.29 million.
- An increase of \$750,000 will be invested in Critical Zone Observatories, coordinated field installations aimed at elucidating the interactions of natural systems in the Earth's near surface environment.
- Research programs across EAR will be augmented by \$10.25 million.

INNOVATIVE & COLLABORATIVE EDUCATION AND RESEARCH **\$56,820,000**

The FY 2009 Request for the Division of Innovative & Collaborative Education and Research (ICER) is \$56.82 million, level with the FY 2008 Estimate.

Innovative and Collaborative Education and Research Funding

(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over	
				FY 2008 Estimate Amount	Percent
Innovative & Collaborative Education and Research	\$56.82	\$56.82	\$56.82	-	-
Major Components:					
Research and Education Grants	51.29	51.22	51.22	-	-
International Collaborations	5.53	5.60	5.60	-	-

About ICER:

ICER supports novel, complex, or partnership projects in both research and education. These investments cut across traditional boundaries within the geosciences, encouraging interdisciplinary activities and responding directly to critical needs of the entire geoscience community. ICER's principal goals are to develop innovative means to initiate and support geoscience education, attract underrepresented groups to careers in the geosciences, foster the interchange of scientific information nationally and internationally, and to join with other parts of NSF in major integrative research and education efforts.

ICER supports a diverse portfolio of research and education activities. Almost 90 percent of the annual budget of ICER is used to support individuals and small groups of researchers, with approximately 44 percent of the total division budget being available to support new research grants.

ICER Priorities for FY 2009:

Education and Broadening Participation in the Geosciences: Cross-divisional education activities include investments in development of curricula and resources specific to broad geoscience education, a leadership activity for geoscience teachers, and support for internet capabilities for geoscience education. In FY 2009, resources will be targeted at increasing the diversity of the geoscience workforce and enhancing the linkages between existing education and diversity projects and LSAMP awards. In a partnership with NASA, NSF will continue support for the GLOBE program. GEO contributes to programs for interdisciplinary graduate education (IGERT) and outreach to students (GK-12).

Interdisciplinary Research: ICER supports a major competition on Carbon and Water in Earth Systems. This research is within the NSF-wide framework for Environmental Research and Education and aims to increase fundamental understanding of the interrelation of physical, chemical, geological, hydrologic, atmospheric, and biological processes that comprise Earth's natural systems. Examples include highly interdisciplinary programs that involve several NSF directorates, such as solicitations on Coupled Natural and Human Systems and Human and Social Dynamics, particularly regarding decision making and uncertainty.

International Collaborations: ICER will continue support of targeted, catalytic international partnerships related to the broad interests of the geosciences, especially those that encourage global and regional scientific observations and information-sharing, and enable participation by U.S. investigators. One example is the Inter-American Institute for Global Change Research, a program that fosters research across the Americas.

Changes from FY 2008:

No changes in programmatic support are requested from the FY 2008 Estimate.

OCEAN SCIENCES

\$353,540,000

The FY 2009 Request for the Division of Ocean Sciences (OCE) is \$353.54 million, an increase of \$43.08 million, or 13.9 percent over the FY 2008 Estimate of \$310.46 million.

Ocean Sciences Funding

(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over	
				FY 2008 Estimate Amount	Percent
Ocean Section	115.64	115.64	130.70	15.06	13.0%
Integrative Programs Section	112.54	112.54	128.54	16.00	14.2%
Marine Geosciences Section	80.58	82.28	94.30	12.02	14.6%
Ocean Sciences	\$308.76	\$310.46	\$353.54	\$43.08	13.9%
Major Components:					
Research and Education Grants	163.52	175.45	195.20	19.75	11.3%
Long-term Ecological Research Centers Centers Program	3.64	3.64	3.64	-	-
Center for Coastal Margin Observation/Prediction Facilities	4.00	4.00	4.00	-	-
Academic Research Fleet	87.94	73.16	87.96	14.80	20.2%
Integrated Ocean Drilling Program (IODP)	34.71	39.26	47.74	8.48	21.6%
Other Ocean Sciences Infrastructure	14.95	14.95	15.00	0.05	0.3%

Totals may not add due to rounding.

About OCE:

Research, education, and infrastructure funded by OCE address the central role of the oceans in a changing Earth and as a national strategic resource. OCE supports interdisciplinary research of the water column to better understand controls on natural processes such as: CO₂ exchange between the oceans and atmosphere and implications for ocean acidification; air-sea exchange of heat and consequences for major storms and hurricanes; impact of natural and anthropogenic change on food webs and fishery stocks; and oceans and human health. Geologic studies of the ocean margins and sub-seafloor investigate past ocean and climate conditions; natural hazards associated with earthquakes, volcanic eruptions and tsunamis; cycles of water and CO₂ in the deep Earth; and biological strategies used in the deep biosphere. Ocean education, formal and informal, draws on the interdisciplinary nature of ocean sciences, sophisticated visualization capabilities and the impact of the oceans on environmental change. Ocean science requires access to the sea; OCE supports research vessels, deep submergence capability including submersibles and autonomous vehicles, and technologically advanced sensors and instrumentation

The OCE portfolio has three highly integrative programmatic areas of support:

- Research grants include awards to individual scientists, collaborative groups, and to several large coordinated projects involving international partners and major shared-use facilities.
- Education grants support graduate and undergraduate research experience, K-12 educational activities, and informal education for the general public. The Centers for Ocean Science Education Excellence (COSEE) form a major education and outreach network for OCE.
- OCE supports acquisition, operation, and maintenance of major world-class facilities required to provide access to the oceans in order to address the highest priority science questions.

OCE supports a diverse portfolio of research, education, and infrastructure activities. Approximately 50 percent of the annual budget of OCE is used to support individuals and small groups of researchers, with approximately 35 percent of the total division budget being available to support new research grants.

OCE Priorities for FY 2009:

Enhancement of the existing OCE programs to maintain a strong, flexible portfolio of research and education grants with commensurate facilities support to create new ideas and technology and attract and train students, is a highest priority.

- The Ocean Observatories Initiative (OOI) remains a high priority to provide sustained time-series observations of dynamic and complex processes within the oceans and below the seafloor. Concept and development activities are ongoing, with Final Design Review planned in early FY 2009.
- The Integrated Ocean Drilling Program (IODP), an international partnership of scientists, research institutions, and agencies, uses ocean drilling to explore the evolution and structure of the Earth and its oceans as recorded in the ocean basins. The program will increase by \$8.48 million in FY 2009, the first full year in which three drilling platforms will be available, after refit of the U.S. drillship (the SODV).
- OCE will contribute to long-term priorities of the Ocean Research Priorities Plan, including the biological and chemical consequences of ocean acidification, and multi-year interdisciplinary studies of the Southern and Atlantic Oceans, key to quantifying the role of the ocean in climate, through strong international partnerships. OCE also supports research in the four near term priorities: comparative analysis of marine ecosystems; the Atlantic meridional overturning circulation and its role in abrupt change; development of sensors for ecosystem observation; and the effects of persistent forcing and extreme events on coastal environments.
- OCE will continue its partnership with EAR and ATM to support interdisciplinary research in two priority areas: Emerging Trends in Biogeochemical Cycles and PaleoPerspectives in Climate Change
- COSEE will begin to incorporate ocean observations from seafloor HDTV and autonomous underwater vehicles and gliders in anticipation of OOI and to foster interactions among research institutions, formal education organizations, and informal education providers like museums to deliver high-quality education programs that promote a deeper public understanding of the oceans, their influence on quality of life and national prosperity, and their growing need for work-force development.

Changes from FY 2008:

- Research and education grants increase by \$18.89 million, to a total of \$195.20 million. OCE will continue to support forefront areas of ocean science, with expanded emphasis on complex systems and the temporal exploration of the oceans. Education and outreach activities will receive continued emphasis: enhancing COSEE, expanding diversity within the research community, and integrating research and education, including the training of young ocean scientists.
- Support for research infrastructure increases \$23.33 million, to a total of \$150.70 million, with increases targeted at the Academic Research Fleet to maintain the number of supported ship days and at the Integrated Ocean Drilling Program. Additional detail for these two programs can be found in the Facilities Chapter.
- Restricted FY 2008 budget growth means that support for the new 3-platform phase of IODP grew only by \$2.56 million; the FY 09 request now includes \$8.48M to bring IODP to previously planned levels.