GEOSCIENCES $792,000,000

The FY 2008 Budget Request for the Directorate for Geosciences (GEO) is $792.0 million, an increase of $47.15 million, or 6.3 percent, over the FY 2007 Request of $744.85 million.

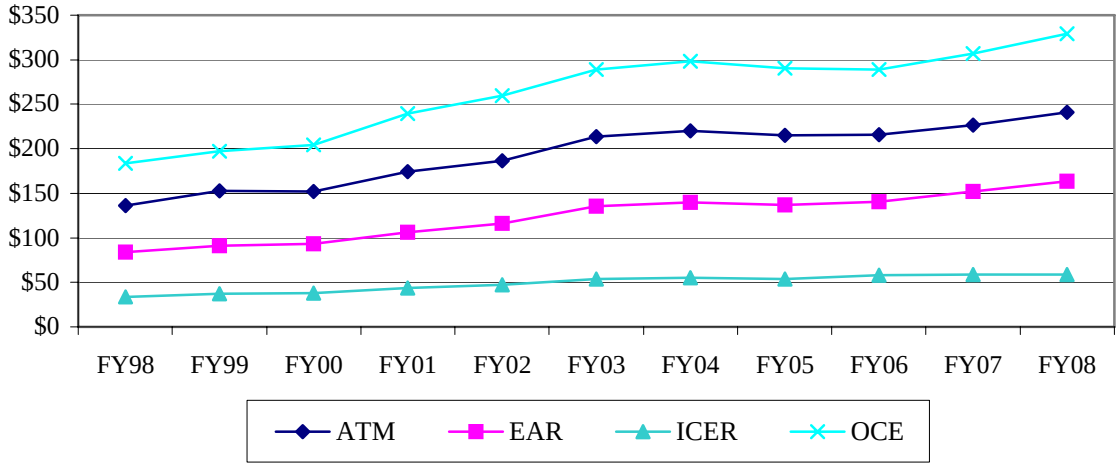
Geosciences Funding
(Dollars in Millions)

	FY 2006 Actual	FY 2007 Request	FY 2008 Request	Change over FY 2007 Request Amount	Change over FY 2007 Request Percent
Atmospheric Sciences (ATM)	$216.13	$226.85	$240.84	$13.99	6.2%
Earth Sciences (EAR)	140.35	152.30	163.30	11.00	7.2%
Innovative & Collaborative Education and Research (ICER)	58.37	58.57	58.57	-	-
Ocean Sciences (OCE)	289.09	307.13	329.29	22.16	7.2%
Total, GEO	$703.95	$744.85	$792.00	$47.15	6.3%

Totals may not add due to rounding.

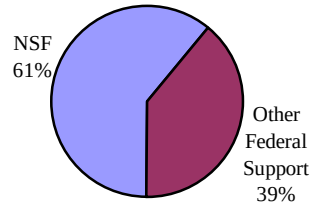
The Directorate for Geosciences (GEO) directly contributes to innovation and competitiveness through its broad portfolio of investments in fundamental research, facilities, and instrumentation that enable discovery, innovation, and integrated education and research activities that increase the effectiveness of the science and engineering workforce. As the principal source of federal funding for university-based fundamental research in the geosciences, GEO 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, weather, earthquakes, marine ecosystem change, and disruptive events in the solar-terrestrial environment.

GEO Subactivity Funding
(Dollars in Millions)



RELEVANCE

Federal Support for Basic Research in Geosciences at Academic Institutions



GEO is the principal source of federal funding for university-based, basic research in the geosciences, providing about 61 percent of the total federal support in these areas. 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 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 the relative importance of natural variability and increased concentrations of greenhouse gases in the atmosphere as they relate to climate change. 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, and drought. Basic research supported by GEO enables preparation for and subsequent mitigation of the effects of these and other inevitable 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.

Activities supported by GEO enable discovery, innovation, and integrated education and research. As such, many GEO programs support the American Competitiveness Initiative theme of fostering innovation. 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 to improve the quality of life. Finally, geoscience research directly contributes to improving our ability to live sustainably on Earth.

GEO is poised to foster advances in fundamental understanding of a variety of Earth system processes ranging from the interaction of the solar wind with Earth’s magnetosphere (space weather) to the structure and dynamics of the Earth’s deep interior and core. GEO is NSF’s lead partner in the U.S. Climate Change Science Program, and plays a critical role in advancing our understanding of the basic drivers of global environmental change and the Earth’s responses. A major thrust in FY 2008 is responding to the near-term priorities contained in the Ocean Research Priorities Plan. These near-term priorities are: Forecasting the Response of Coastal Ecosystems to Persistent Forcing and Extreme Events, Comparative Analysis of Marine Ecosystem Organization, Sensors for Marine Ecosystems, and Assessing Meridional Overturning Circulation Variability. A major theme in FY 2008 is supporting the infrastructure which has become essential to the successful conduct of modern geoscience research. Investment in the operation of the EarthScope facility and Ocean Drilling activities are both receiving significantly increased investment in FY 2008.

Summary of Major Changes by Division ***(Dollars in Millions)***

FY 2007 Request, GEO……..……..……..$744.85

Atmospheric Sciences (ATM) +13.99

Increased support will augment research to understand and predict environmentally 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 and international programs 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 continued operation at FY 2007 levels.

Earth Sciences (EAR) +$11.00

Increased funding is focused on operational and scientific support of the EarthScope facility, which is being constructed through the MREFC account. Research support will increase slightly to enable maintenance of funding rates at FY 2007 levels.

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

In FY 2008, 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) +$22.16

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, which utilizes the drillship currently undergoing a refit supported through the MREFC Account. Increased support will also target the near-term research priorities of the Ocean Research Priorities Plan.

Subtotal, Changes +$47.15

FY 2008 Request, GEO……...……..$792.00

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

FY 2007 Request, GEO...……...……...…….$744.85

<u>Discovery Research and Innovation</u> +$15.29

Disciplinary and Interdisciplinary Research (-$1.71 million)

Geoscience investments in fundamental research will continue to advance the frontiers of knowledge and discovery by working across traditional boundaries and encouraging multidisciplinary, cutting-edge, and high-impact research. Contributing to American technical innovation and scientific leadership, these investments directly support priorities associated with the American Competitiveness Initiative as well as the agency-wide research and development priorities, particularly those related to innovation, understanding global

environmental issues, natural disasters, and improving the future quality of life. A small amount of support from existing programs is being redirected to emphasize activities that support other priority investments.

Ocean Research Priorities Plan (+$17.0 million)

GEO will support the near-term priorities presented in the Ocean Research Priorities Plan: Forecasting the Response of Coastal Ecosystems to Persistent Forcing and Extreme Events, Comparative Analysis of Marine Ecosystem Organization, Sensors for Marine Ecosystems, and Assessing Meridional Overturning Circulation Variability. Research activities across the geosciences will support greater understanding in these key areas.

Transformational Facilities and Infrastructure +$29.52

Academic Research Fleet (-$100,000)

GEO is the primary supporter of operations of the national Academic Research Fleet. Over the past five years, the cost of operational support has risen significantly, driven by many factors including increased costs for fuel, personnel, and new port security requirements. For example, in FY 2003, GEO's investment of $65.20 million in the Academic Research Fleet supported approximately 3,000 ship operating days. Although funding has increased since then, the number of ship operating days supported has fallen to 2,000 days at sea, far short of the expected demand of approximately 3,000 days. Despite an increase for ship operations of $3.10 million, to a total of $80.60 million, only 2,000 ship operating days can be supported.

In addition to capacity needs, the capability of the Academic Research Fleet is declining as many vessels approach the end of their safe operational lifetimes and their instrumentation becomes outdated. Two acquisitions are underway to respond to the most pressing needs. One is the first in a planned series of Regional-class Research Vessels ($14.0 million, a reduction of -$1.10 million from FY 2007) to replace aging and less capable ships. The second acquisition is the development and construction of a next-generation, human-occupied research submersible to replace the aging ALVIN ($3.0 million, a reduction of $2.10 million from FY 2007). This reduced level was planned as construction shifts into the less costly aspects of outfitting.

EarthScope (+$10.0 million)

Operational support of the EarthScope facility being constructed through the MREFC account will increase by $10.0 million to a total of $21.61 million. This level of operational support will enable operation of the facility as additional elements become operational during FY 2008.

Incorporated Research Institutions for Seismology (IRIS) (-$1.50 million)

Operational support of the IRIS facility will total $11.40 million, less than the FY 2007 Request but level with the FY 2006 operating budget. This reduction will result in a slowing of the rate of repair, replacement, and upgrade of seismic stations.

Digital Libraries (-$1.60 million)

In FY 2008, support for GEO's digital library program will end. This program proved the value of online, digital learning resources related to the geosciences, but due to the growth of the internet and greatly increased usability through commercial search capabilities, support of this activity is no longer needed.

Ocean Drilling Activities (+$12.20 million)

The Integrated Ocean Drilling Program, including operation of a new Scientific Ocean Drilling Vessel acquired and outfitted with support from the MREFC account, will increase by $12.20 million to a total of $38.0 million. This increase reflects the start of full program operations.

Ocean Drilling Program (-$2.0 million)

The Ocean Drilling Program officially ended in FY 2003. FY 2007 was the final year of support for ramp-down activities associated with this successful program.

Ocean Observatories (+$6.80 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) and proposed as a new MREFC start in FY 2007, will increase by $6.80 million to a total of $15.10 million. This increase will support operation of initial elements of the observatory as they are installed.

Research Resources (+$1.70 million)

Support for smaller infrastructure investments and community research resources will increase by $1.70 million. Primarily in the observation-intensive atmospheric sciences, these additional investments will enable infrastructure services to be maintained at FY 2007 levels.

National Center for Atmospheric Research (NCAR) (+$4.02 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. Research activities across NCAR will increase by $4.02 million, or about 4.7 percent, enabling continued research and facility operations at approximately the same level as FY 2007.

Stewardship +$2.34

GEO will increase support for administrative activities necessary to enable NSF to achieve its strategic goals. This includes the cost of Intergovernmental Personnel Act appointments and contractors performing administrative functions.

Subtotal, Changes +$47.15

FY 2008 Request, GEO…….……...….$792.00

GEO Facilities Funding
(Dollars in Millions)

Facilities	FY 2006 Actual	FY 2007 Request	FY 2008 Request	Change over FY 2007 Request Amount	Change over FY 2007 Request Percent
Academic Research Fleet	$76.21	$97.70	$97.60	-$0.10	-0.1%
Regional Research Vessel	*3.63*	*15.10*	*14.00*	*-1.10*	*-7.3%*
RHOV Construction (R/V Alvin Replacement)	*8.63*	*5.10*	*3.00*	-2.10	*-41.2%*
R/V Langseth Construction (R/V Ewing Replacement)	*1.74*	-	-	-	*N/A*
Ship Operation and Upgrade	*62.21*	*77.50*	*80.60*	*3.10*	*4.0%*
Advanced Modular Incoherent Scatter Radar (AMISR)	7.50	-	-	-	N/A
Alaska Regional Research Vessel (ARRV)	0.03	-	-	-	N/A
EarthScope: USArray, SAFOD, PBO	6.72	11.61	21.61	10.00	86.1%
Incorporated Research Institutions for Seismology (IRIS)	11.41	12.90	11.40	-1.50	-11.6%
Integrated Ocean Drilling Program (IODP)	28.56	4.50	4.64	0.14	3.1%
Nanofabrication (NNIN)	0.49	0.49	0.49	-	-
Ocean Observatories	4.15	8.30	15.10	6.80	81.9%
ODP Facilities	3.63	2.00	-	-2.00	-100.0%
Scientific Ocean Drilling Vessel (SODV)	-	21.30	33.36	12.06	56.6%
NCAR	83.48	85.73	89.75	4.02	4.7%
NAIC	1.69	1.70	1.70	-	-
Total, GEO	$223.87	$246.23	$275.65	$29.42	11.9%

NSF-WIDE INVESTMENTS

In FY 2008, the Directorate for Geosciences will support research and education efforts related to broad, Foundation-wide investments in a number of areas including NSF's multidisciplinary priority areas and the Administration's interagency R&D priorities.

GEO NSF-wide Investments
(Dollars in Millions)

	FY 2006 Actual	FY 2007 Request	FY 2008 Request	Change over FY 2007 Request Amount	Change over FY 2007 Request Percent
Biocomplexity in the Environment	$36.85	$26.11	-	-$26.11	-100.0%
Climate Change Science Program	149.35	157.72	160.72	3.00	1.9%
Cyberinfrastructue	71.35	75.00	75.00	-	-
Human and Social Dynamics	1.35	1.35	1.35	-	-
International Polar Year	-	5.00	5.00	-	-
Mathematical Sciences	7.00	3.53	-	-3.53	-100.0%
National Nanotechnology Initiative	9.00	9.65	9.65	-	-
Networking and Information Technology R&D	14.56	14.56	14.56	-	-

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. Emphasis on the interaction of human and natural systems will continue. Future directions for key components of this program will be influenced by an external review conducted in early FY 2007.

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 agency-wide 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 2008, increased emphasis will be placed on understanding Earth's water cycle, carbon cycle, and past and potential future climate variability and change.

Cyberinfrastructure: Research advances in the geosciences increasingly depend on the presence of underlying cyberinfrastructure to bridge systems and make data interoperable across platforms. Linked to the process of innovation and the ACI, GEO will continue to invest in making computation available to geoscientists through the acquisition and operation of next-generation computational systems.

Human and Social Dynamics: GEO continues funding of $1.35 million to engage the social science community in understanding and predicting behavior in response to extreme events (earthquakes, tsunamis, hurricanes, tornados, solar disruptions, etc.) and other natural processes affecting society.

International Polar Year (IPY): As part of NSF's IPY activities, GEO will focus on modeling in the polar regions, including ocean currents, climate, and extent of sea ice coverage. Also, research activities associated with the Integrated Ocean Drilling Program are planned in the Arctic during the IPY period.

Mathematical Sciences: With the conclusion of this priority area in FY 2007, key components of investment in Mathematical Sciences will be incorporated into a follow-on joint GEO-Math activity currently under development.

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 utilizing nanoscale phenomena as catalysts for environmental remediation.

Networking and Information Technology R&D (NITRD): 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. 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.

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 76 percent in FY 2006. 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 87 percent.

To ensure the highest quality in processing and recommending proposals for awards, GEO convenes Committees of Visitors (COV), 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 2006, GEO convened COVs for the UCAR and Lower Atmospheric Facilities Section of the ATM Division. COVs also were convened for the Ocean and Marine Geosciences Sections of the OCE Division in 2006 and directorate-wide education and diversity programs in 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 2008 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.

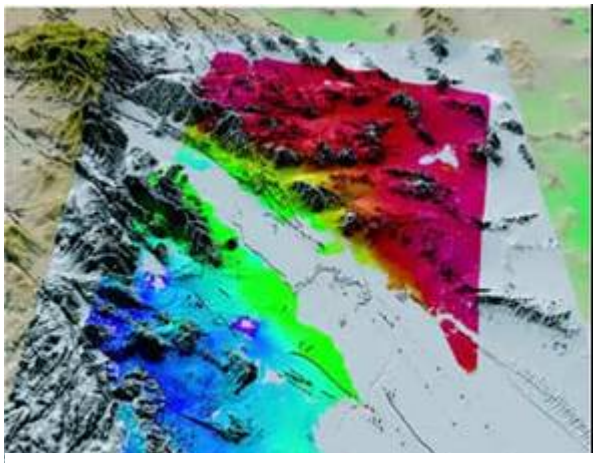
Geosciences
By Strategic Outcome Goal
(Dollars in Millions)

	FY 2006 Actual	FY 2007 Request	FY 2008 Request	Change over FY 2007 Request Amount	Percent
Discovery	$387.43	$396.97	$412.26	$15.29	3.9%
Learning	29.55	31.39	31.39	-	-
Research Infrastructure	281.06	311.08	340.60	29.52	9.5%
Stewardship	5.91	5.41	7.75	2.34	43.3%
Total, GEO	$703.95	$744.85	$792.00	$47.15	6.3%

Totals may not add due to rounding.

GEO will continue its commitment to education, training, and increasing diversity in FY 2008. The FY 2008 budget will maintain award size and 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, development of new infrastructure remains a priority, with ongoing support for the acquisition of new regional research vessels and increased support for the operation of the EarthScope facility being constructed through the MREFC account and the Integrated Ocean Drilling Program.

Recent Research Highlights

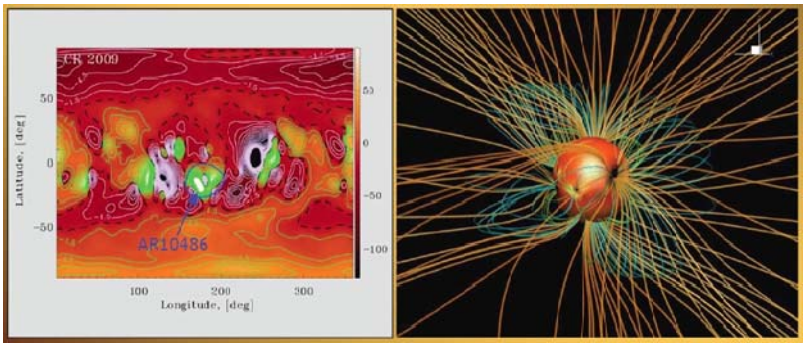


Surface deformation from radar interferograms across the Salton Sea shows movement of the San Andreas fault. Digital terrain from Shuttle Radar Topography Mission. *Credit: Yuri Fialko.*

► **San Andreas Fault Set for the 'Big One:'** Yuri Fialko of the Scripps Institution of Oceanography at the University of California, San Diego, the recipient of a GEO CAREER award in 2004, has produced a new depiction of the earthquake potential of the San Andreas Fault's southern, highly populated section. The new study indicates that the fault has been stressed to a level sufficient for an earthquake of magnitude seven or greater, and that the risk of a large earthquake in this region may be increasing faster than researchers had believed.

Fialko used remote sensing techniques like GPS and satellite radar data, geologic records, and seismic data to observe strain build-up along the southern part of the fault. He found evidence that the southern San Andreas has accumulated about six to eight meters of slip "deficit." If released at one time, this would result in a Magnitude 8 earthquake, roughly the size of the 1906 San Francisco earthquake. Fialko also found that the two sides of the fault, the North American tectonic plate and the Pacific plate, exhibit different structural characteristics. The Pacific plate is more rigid than its neighbor. This research is important not only for long-term hazard planning in the densely populated region of Southern California, but also for providing new, precise analyses and methods to help earthquake scientists discover how faults operate. (EAR).

► **Improved Solar Forecasting Through Advanced Simulations of the Sun:** Forecasting hazards posed by the "weather" in space can be as important — and as difficult — as forecasting thunderstorms, tornadoes and hurricanes on the ground. The highly energetic charged particles emitted by the Sun can endanger astronauts, damage the electronics on satellites and planetary probes, increase the radiation exposure of crews and passengers in high-altitude aircraft, and even affect electrical systems on the Earth's surface.



Map of the radial component of the Sun's magnetic field preceding the CME (coronal mass ejection) of Oct 28, 2003. (Above Left); Computed steady-state coronal magnetic field for the same date, with solar wind flow vectors.(Above Right) The CME later erupted from the active region labeled "AR10486" in blue on the left. *Credit: Ilia Roussev, University of Hawaii.*

Now, however, Ilia Roussev at the University of Hawaii has developed a computer model that could improve space weather forecasts significantly. Based on a well-established, but highly-complex physical theory known as magnetohydrodynamics, Roussev's model accurately simulates the flares and other solar eruptions that emit the high-energy particles. (ATM).

► **Improving Hurricane Modeling by Including Ocean Waves**: NSF-funded research at the University of Rhode Island has greatly improved scientists' understanding of how waves at the ocean's surface influence the formation of hurricanes.

The role of waves has long been one of the main uncertainties in modeling tropical hurricanes and their resulting storm surge.

The advance provided by the new research is significant, especially for strong hurricanes. When the new model of wave influence was tested on a simulation called the Geophysical Fluid Dynamics Laboratory/University of Rhode Island hurricane model, the hurricane tracking estimates improved by five to seven percent and the hurricane intensity prediction improved by up to 20 percent. The results were so on-target that they will be incorporated in the National Weather Service's operational version of the model, and will be used by the National Hurricane Center in real-time hurricane forecasts. (OCE).

► **Finding and Keeping Kids in the Earth Science Pipeline from 6th Grade to Post-college:** Researcher Alan Smith and his team at Cal State San Bernadino have completed an ambitious project to recruit and retain underrepresented ethnic groups in the earth sciences from 6th grade to post-college. In an initial survey asking minority children why they were not majoring in geology, the top reasons were lack of exposure to the geosciences and lack of knowledge about geoscience careers.

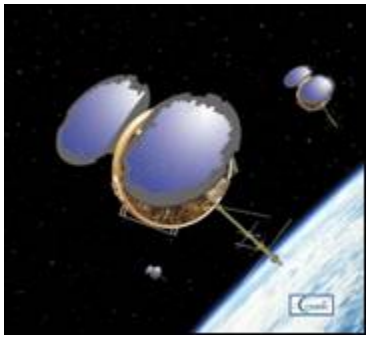
Shoe-box modeling of plate tectonics.
Credit: Sally McGill

Armed with these results, the team conducted 169 outreach sessions over a three-year period that involved more than 12,000 contact hours with 5,700 students. Most students were middle- or high-school students, and three quarters were from underrepresented groups in the geosciences (52 percent were Hispanic, 13 percent African American, five percent Native American, and 4 percent Pacific Islander).

Group activities included hikes to the San Andreas fault and hands-on exercises related to plate tectonics and earthquakes. Hands-on activities were modified to enhance students' familiarity with the scientific method. Students began by making observations from and asking questions about maps of the Earth. One of the observations they often noted was that the coastlines of Africa and South America look like they would fit together. They also noticed the mid-ocean ridges and trenches on the sea floor. A computer animation of world seismicity was shown so that students could make observations about where earthquakes occur.

Another activity was a bi-annual Global Positioning System (GPS) campaign. This campaign allowed students to work with scientists and use state-of-the-art GPS receivers to precisely determine the location of benchmarks on both sides of the San Andreas and San Jacinto faults. From these measurements, the students determined the bending of the tectonic plates that will eventually lead to slip along these faults as major earthquakes. Students worked with scientists to interpret the GPS data in terms of how fast the faults were slipping. Results were presented at meetings of the American Geophysical Union and the Southern California Earthquake Center. The data were also shared with the Southern California Earthquake Data Center (www.scecdc.scec.org) for use by other scientists around the country and around the world. (ICER).

► **New Satellites Enhance Weather and Climate Change Forecasts:** A globe-spanning constellation of six satellites, expected to improve weather forecasts, monitor climate change, and enhance space weather research headed into orbit in April 2006. The low-orbiting satellites (called COSMIC) will be the first to provide atmospheric data daily in real time over thousands of points on Earth for both research and operational weather forecasting. The satellites will measure the bending of radio signals from the U.S. Global Positioning System (GPS) as the signals pass through Earth's atmosphere.



A constellation of satellites, called COSMIC, will transmit new information for studies of weather and climate. Credit: *University Corporation for Atmospheric Research/National Center for Atmospheric Research.*

Temperature and water vapor profiles derived from the GPS data will help meteorologists observe, research, and forecast hurricanes, typhoons, and other storm patterns over the oceans. The stability, consistency, and accuracy of the measurements will provide critical new information to scientists quantifying long-term climate change trends. (ATM).

► **A Transformation in Hydrologic Science:** Three NSF-funded hydrologists have made great progress in understanding what happens to a river system when it is modified, whether by engineered works or by stream restoration.

- Heidi Nepf (MIT) has applied the principles of physics to determine how vegetation on the channel beds and stream banks affects sedimentation, nutrient transport, and riverbank stability, both during normal flow and flood stage.
- Ellen Wohl (Colorado State) has determined the role of woody debris in shaping river channels. This information places river restoration strategies in the context of a historical view of a river channel, and allows scientists and environmental managers to balance the benefits of river restoration strategies against the benefits of reducing flood potential.
- Peter Kitanidis (Stanford) has integrated these elements. His models of river flow and transport through pools and riffles incorporates riverbed characteristics and flow interactions with banks and in-river obstacles.

In combination, the three hydrologists' work will help engineers, ecologists, and water resource managers balance engineered performance against the quality of the natural system, and will help society as a whole mitigate environmental degradation and extreme events in river systems around the world. (EAR).

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 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate
Senior Researchers	4,120	4,200	4,300
Other Professionals	2,924	3,000	3,100
Postdoctorates	573	600	650
Graduate Students	2,307	2,300	2,400
Undergraduate Students	4,342	4,500	4,600
Total Number of People	14,266	14,600	15,050

GEO Funding Profile

	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate
Statistics for Competitive Awards:			
Number	1,424	1,500	1,600
Funding Rate	31%	31%	31%
Statistics for Research Grants:			
Number of Research Grants	1,113	1,100	1,200
Funding Rate	28%	28%	28%
Median Annualized Award Size	$110,394	$111,000	$113,000
Average Annualized Award Size	$148,499	$149,000	$155,000
Average Award Duration, in years	3	3	3

ATMOSPHERIC SCIENCES $240,840,000

The FY 2008 Request for the Division of Atmospheric Sciences (ATM) is $240.84 million, an increase of $13.99 million, or 6.2 percent, over the FY 2007 Request of $226.85 million.

Atmospheric Sciences Funding

(Dollars in Millions)

	FY 2006 Actual	FY 2007 Request	FY 2008 Request	Change over FY 2007 Request Amount	Change over FY 2007 Request Percent
Atmospheric Sciences Research Support	132.65	141.12	151.09	9.97	7.1%
National Center for Atmospheric Research	83.48	85.73	89.75	4.02	4.7%
Atmospheric Sciences	**$216.13**	**$226.85**	**$240.84**	**$13.99**	**6.2%**
Major Components					
Research and Education Grants	96.67	103.12	111.39	8.27	8.0%
Centers Programs					
Center for Integrated Space Weather Modeling	4.00	4.00	4.00	-	-
Center for Atmospheric Process Modeling	-	4.00	4.00	-	-
Facilities					
National Center for Atmospheric Research (NCAR)	83.48	85.73	89.75	4.02	4.7%
Research Resources and Infrastructure	31.98	30.00	31.70	1.70	5.7%

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. The Division of Atmospheric Sciences 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 42 percent of the annual budget of ATM is used to support individuals and small groups of researchers, with approximately 20 percent of the total division budget being available to support new research grants.

ATM priorities for FY 2008:

- 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: including 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 to improve predictions of fundamental space, atmospheric, and Earth system processes;
- Cyberinfrastructure and Numerical Models: Improvements which will allow new discoveries, greater access to atmospheric data, and improved understanding of the atmospheric environment; and
- Interagency and International Programs: Continued 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.

Changes from FY 2007

- Research and education grants and centers increase by $8.27 million, to a total of $111.39 million, and include:
  - an increase of $2.0 million in research on natural hazards (i.e. severe weather and space weather);
  - an increase of $2.0 million for cyberinfrastructure investments; and
  - an increase of $4.27 million in other disciplinary programs.

- Facilities increase by $5.72 million to a total of $121.45 million, and include:
  - an inflationary increase of $4.02 million for NCAR; and
  - an increase of $1.70 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 $163,300,000

The FY 2008 Request for the Division of Earth Sciences (EAR) is $163.30 million, an increase of $11.0 million, or 7.2 percent, over the FY 2007 Request of $152.30 million.

Earth Sciences Funding

(Dollars in Millions)

	FY 2006 Actual	FY 2007 Request	FY 2008 Request	Change over FY 2007 Request Amount	Change over FY 2007 Request Percent
Earth Science Project Support	105.77	115.90	126.90	11.00	9.5%
Instrumentation and Facilities	34.58	36.40	36.40	-	-
Earth Sciences	**$140.35**	**$152.30**	**$163.30**	**$11.00**	**7.2%**
Major Components:					
Research and Education Grants	92.92	98.63	101.01	2.38	2.4%
Centers Programs					
Sustainability of Semi-Arid Hydrology and Riparian Areas	3.29	3.32	3.32	-	-
National Center for Earth-Surface Dynamics	3.38	3.36	3.48	0.12	3.6%
Facilities					
Incorporated Research Institutions for Seismology (IRIS)	11.41	12.90	11.40	-1.50	-11.6%
EarthScope Operations	6.72	11.61	21.61	10.00	86.1%
Other Earth Sciences Infrastructure	22.63	22.48	22.48	-	-

About EAR:

The Earth functions as a complex system that affects every aspect of our daily lives. The clean water we require to sustain life is made available through the hydrologic cycle. Soil forming processes are absolutely essential to agriculture. Our energy is largely provided by fossil fuels discovered in the subsurface and pumped or mined. Earthquakes 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. 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 64 percent of the annual budget of EAR is used to support individuals and small groups of researchers, with approximately 36 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 NSF's EarthScope project), and establish observatories for study of the Earth's environmental systems. One way of addressing the Earth's complexity is through geoinformatics, the collaboration between geoscientists and computer scientists to solve complex scientific questions. 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. EAR supports geoinformatics research and activities devoted to analyzing, modeling, and developing interactive capabilities for extensive and diverse data sets. Projects currently supported include:

- Consortia of universities, such as the Incorporated Research Institutes 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 system gave emergency personnel the first indication of the location and severe damage potential of the Great Sumatra earthquake and tsunami of December 2004.
- The Consortium of Universities for the Advancement of Hydrologic Science, Inc. (CUAHSI) is developing 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.
- In the developmental stages are projects linking data sets bearing on sedimentary sequences and geologic time. This will greatly improve our understanding of the Earth's surface environments.
- 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. Their results are providing significant input to disaster preparedness and a better understanding of fundamental earthquake processes.
- The Geoscience Network (GEON) consortium is a collaboration of computer scientists and geoscientists working on a variety of fronts to create cyberinfrastructure of applicability to earth scientists. They are also working on a system that allow the user to create synthetic seismograms using the Teragrid, on services for processing LiDAR imagery, on three- and four-dimensional visualization and on educating the next generation of cyber-Earth scientists.
- 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 2008:

- EarthScope Operations and Science Support: The new EarthScope facility, being constructed through the MREFC account, is continuing to ramp up operations and enabling new science at the intersection of several subfields within the earth sciences. 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 MREFC 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 2007:

- EAR will continue to increase by $10.0 million the funding of Operations and Maintenance of the EarthScope facility,
- Funds of $1.0 million 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.
- A $1.50 million reduction in funding for IRIS will shift funds to other earth science research activities.

INNOVATIVE & COLLABORATIVE EDUCATION AND RESEARCH $58,570,000

The FY 2008 Request for the Division of Innovative & Collaborative Education and Research (ICER) is $58.57 million, level with the FY 2007 Request.

Innovative and Collaborative Education and Research Funding

(Dollars in Millions)

	FY 2006 Actual	FY 2007 Request	FY 2008 Request	Change over FY 2007 Request Amount	Change over FY 2007 Request Percent
Innovative & Collaborative Education and Research	**$58.37**	**$58.57**	**$58.57**	**-**	**-**
Major Components:					
Research and Education Grants	53.13	53.17	53.17	-	-
International Collaborations	5.24	5.40	5.40	-	-

About ICER:

The Innovative and Collaborative Education and Research subactivity 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. Approximately 60 percent of the annual budget of ICER is used to support individuals and small groups of researchers, with approximately 40 percent of the total division budget being available to support new research grants.

ICER Priorities for FY 2008:

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 2008, 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 2007:

No changes in programmatic support are requested from the FY 2007 level.

OCEAN SCIENCES $329,290,000

The FY 2008 Request for the Division of Ocean Sciences (OCE) is $329.29 million, an increase of $22.16 million, or 7.2 percent over the FY 2007 Request of $307.13 million.

Ocean Sciences Funding

(Dollars in Millions)

	FY 2006 Actual	FY 2007 Request	FY 2008 Request	Change over FY 2007 Request Amount	Change over FY 2007 Request Percent
Ocean Section	107.89	114.62	118.82	4.20	3.7%
Integrative Programs Section	105.77	112.37	117.33	4.96	4.4%
Marine Geosciences Section	75.43	80.14	93.14	13.00	16.2%
Ocean Sciences	**$289.09**	**$307.13**	**$329.29**	**$22.16**	**7.2%**
Major Components:					
Research and Education Grants	161.12	151.76	158.66	6.90	4.5%
Long-term Ecological Research Centers	3.13	3.50	3.50	-	-
Centers Program					
Center for Coastal Margin Observation/Prediction	-	4.00	3.96	-0.04	-1.0%
Facilities					
Academic Research Fleet	76.21	97.70	97.60	-0.10	-0.1%
Integrated Ocean Drilling Program (IODP)	28.56	25.80	38.00	12.20	47.3%
Other Ocean Sciences Infrastructure	20.07	24.37	27.57	3.20	13.1%

About OCE:

Research, education, and infrastructure funded by OCE addresses the central role the oceans play in an ever-changing Earth and as a strategic resource for the nation. OCE supports research that combines the chemistry, physics, and biology of the oceans today to better understand the natural processes involved with topics such as: CO_2 exchange between the oceans and atmosphere and its implications for ocean acidification; air-sea exchange of heat and its consequences for major storms and hurricanes; impact of natural and anthropogenic change on food webs and fishery stocks; and the role of the oceans in human health. Geologic studies of the ocean margins and sub-seafloor, incorporating biology, chemistry, and physics, investigate past ocean and climate conditions; the natural hazards associated with earthquakes, volcanic eruptions and tsunamis; the natural cycles of water and CO_2 in the deep Earth; and the biological strategies used in the deep biosphere. The strongly interdisciplinary nature of ocean sciences and the increasingly sophisticated remote sensing and visualization of the ocean and seafloor now available provide a strong framework for both formal and informal education. Ocean science requires access to the sea; OCE supports research vessels, manned and unmanned deep diving submersibles, and a wide range of technologically advanced sensors and observational instrumentation.

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

- OCE research grants include awards to individual scientists, to small collaborative groups, and to several large coordinated projects involving international partners and major shared-use facilities.
- OCE education grants support graduate and undergraduate research experiences, 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 also 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 52 percent of the annual budget of OCE is used to support individuals and small groups of researchers, with approximately 34 percent of the total division budget being available to support new research grants.

OCE Priorities for FY 2008:

Maintaining a strong, flexible program of research and education grants and facilities support to create new ideas and technology and attract and train students, are the highest priorities in this portfolio.

- The Ocean Observatories Initiative (OOI) remains a high priority to address the need for sustained time-series observations of the many highly dynamic and complex ocean processes and characteristics within the ocean and below the seafloor. OOI deployments will provide power and two-way communication to re-configurable arrays of ocean sensors. Funding increases by $6.80 million in FY 2008.
- The Integrated Ocean Drilling Program (IODP) is an international partnership of scientists, research institutions, and agencies using ocean drilling to explore the evolution and structure of Earth and its oceans as recorded in the ocean basins. The program will increase by $12.20 million in FY 2008, with three platforms for drilling, including the US contribution of the Scientific Ocean Drilling Vessel.
- A NSF Science and Technology Center (STC) for Coastal Margin Observation and Prediction will undertake its first full year of operations, to create the scientific infrastructure necessary to obtain reliable quantitative descriptions and analyses of integrated physical, chemical, and biological variables in estuaries, freshwater plumes, and continental shelves.
- Community driven numerical modeling systems in marine geology and oceanography are developing integrated hardware and software packages to enable scientists to better combine observations and theory, providing a framework for scientific advances and their application to national needs.
- OCE will build on past investments to contribute to the four near term priorities in the national Ocean Research Priorities Plan: 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.
- COSEE partnerships foster interactions among research institutions, formal education organizations, and informal education providers like museums to deliver high-quality education programs that integrate research to 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.
- Providing scientists with access to the sea via modern infrastructure is essential. Building upon recommendations of the National Academy of Sciences and the Federal Oceanographic Facility Committee (FOFC), several projects will continue, including the construction of regional-class research vessels to replace aging and less capable ships.

Changes from FY 2007:

- Research and education grants increase by $6.90 million, to a total of $158.66 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 $15.30 million, to a total of $163.17 million, with increases targeted at the Integrated Ocean Drilling Program and the Ocean Observatories Initiative.