

DIRECTORATE FOR GEOSCIENCES (GEO)**\$787,050,000**
-\$120,750,000 / -13.3%**GEO Funding**
(Dollars in Millions)

	FY 2018 Actual	FY 2019 (TBD)	FY 2020 Request	Change over	
				FY 2018 Actual Amount	Percent
Division of Atmospheric and Geospace Sciences (AGS)	\$276.10	-	\$221.97	-\$54.13	-19.6%
Division of Earth Sciences (EAR)	179.69	-	156.97	-22.72	-12.6%
Integrative and Collaborative Education & Research (ICER)	85.75	-	93.20	7.45	8.7%
Division of Ocean Sciences (OCE)	366.26	-	314.91	-51.35	-14.0%
Total	\$907.80	-	\$787.05	-\$120.75	-13.3%

About GEO

GEO supports basic research that advances the frontiers of knowledge and drives technological innovation while improving our understanding of the many processes that create and sustain vital natural resources on which society depends. Our mineral, energy, and water resources result from diverse Earth processes including the planet's water cycle, interactions across the land-ocean interface, the behavior of ice sheets, and geologic processes responsible for hydrocarbon energy sources and strategic minerals. Basic research supported by GEO contributes to the understanding of these processes and the resources that result from them. In addition, lives are saved and property is preserved by better forecasting and understanding of natural environmental hazards such as earthquakes, tornadoes, drought, and solar storms. GEO-supported research improves society's preparation for the effects of these and other disruptive natural events, and GEO prioritizes support for interdisciplinary studies that contribute directly to national research priorities such as mitigating the impacts of hazardous events and understanding future availability and distribution of fresh water.

Leveraging the knowledge and techniques of many other disciplines, GEO strongly promotes the growth of convergence research across all fields of science. GEO activities support and promote many of NSF's Big Ideas. OPP within GEO, in coordination with ENG and SBE, manages NSF's NNA Big Idea, with \$30.0 million in the ICER division held in stewardship to support crosscutting NNA research. GEO programs also contribute to HDR through the EarthCube activity. As observational sciences, geosciences rely on vast archives of data to forge new knowledge about the Earth. GEO also participates in URoL, primarily with focuses on microbiomes in the aquatic realm.

In addition, OPP operates as part of GEO; more information on OPP can be found in the OPP narrative in this chapter.

GEO provides about 58 percent of the federal funding for basic research at academic institutions in the atmospheric, earth, and ocean sciences.

Major Investments

GEO Major Investments

(Dollars in Millions)

Area of Investment	FY 2018 Actual	FY 2019 (TBD)	FY 2020 Request	Change over FY 2018 Actual	
				Amount	Percent
INFEWS	\$7.00	-	\$8.00	\$1.00	14.3%
IUSE	5.82	-	5.70	-0.12	-2.0%
I-Corps™	0.60	-	0.60	-	-
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NSF's Big Ideas					
<i>NNA Stewardship</i>	-	-	30.00	30.00	N/A

Major investments may have funding overlap and thus should not be summed.

- INFEWS (\$8.0 million): In FY 2020, NSF is continuing to build and support an interdisciplinary investment to study the food-energy-water nexus through INFEWS to enable accelerated research of this nexus.
- IUSE (\$5.70 million): Funding for the NSF-wide IUSE activity continues to support development of the next generation of geoscientists.

GEO Funding for Centers Programs and Facilities

GEO Funding for Centers Programs

(Dollars in Millions)

	FY 2018 Actual	FY 2019 (TBD)	FY 2020 Request	Change over FY 2018 Actual	
				Amount	Percent
Total	\$5.00	-	\$1.30	-\$3.70	-74.0%
STC: Center for Dark Energy	5.00	-	1.30	-3.70	-74.0%
Biosphere Investigations (OCE)					

For detailed information about NSF Centers programs, please see the NSF-Wide Investments chapter.

GEO Funding for Major Multi-User Facilities

(Dollars in Millions)

	FY 2018 Actual ¹	FY 2019 (TBD)	FY 2020 Request	Change over	
				FY 2018 Actual Amount	Actual Percent
Total	\$344.53	-	\$293.53	-\$51.00	-14.8%
Academic Research Fleet (ARF)	86.03	-	74.10	-11.93	-13.9%
Arecibo Observatory	5.42	-	2.13	-3.29	-60.7%
Geodetic Facility for the Advancement of GEoscience (GAGE)	11.49	-	11.86	0.37	3.2%
International Ocean Discovery Program (IODP)	47.55	-	45.80	-1.75	-3.7%
National Center for Atmospheric Research (NCAR)	126.34	-	99.70	-26.64	-21.1%
Ocean Observatories Initiative (OOI)	44.08	-	38.00	-6.08	-13.8%
Seismological Facility for the Advancement of GEoscience (SAGE)	23.61	-	21.94	-1.67	-7.1%

¹ In FY 2018, Congress appropriated additional funding to NSF above the Request level, which was in part allocated to several facilities for one time enhancements, forward funding of future activities, and/or development and design.

For detailed information on individual facilities, please see the Facilities and the Major Research Equipment and Facilities Construction chapters.

Funding Profile

GEO Funding Profile			
	FY 2018		
	Actual	FY 2019	FY 2020
	Estimate	(TBD)	Estimate
Statistics for Competitive Awards:			
Number of Proposals	3,222	-	3,300
Number of New Awards	1,201	-	1,050
Funding Rate	37%	N/A	32%
Statistics for Research Grants:			
Number of Research Grant Proposals	2,853	-	2,900
Number of Research Grants	990	-	850
Funding Rate	35%	N/A	29%
Median Annualized Award Size	\$162,948	-	\$163,000
Average Annualized Award Size	\$215,234	-	\$215,000
Average Award Duration, in years	2.9	-	3.0

As NSF's Big Ideas ramp up, a net increase in incoming proposals is expected, which will likely result in a net reduction in overall funding rates in GEO.

Program Monitoring and Evaluation

External Program Evaluations and Studies:

- In FY 2018, EAR funded a three-year study on Catalyzing Opportunities for Research in Earth Sciences by the National Academies of Science, Engineering, and Medicine (the National Academies). This study will identify high research priorities for the division. The first public meeting took place in November 2018.
- The Science, Engineering, and Education for Sustainability (SEES) program, which ended in FY 2017, was assessed, with the final report delivered in FY 2018. The evaluation under sponsorship of GEO

and OIA included the following tasks: (1) examining the effectiveness of SEES, (2) completing a historical review of NSF’s sustainability efforts in the past 15 years, and (3) reviewing the SEES portfolio solicitations from 2010 to 2014. The contractor’s analyses produced interesting findings, including:

- Collaboration intensity of SEES teams is higher than that of non-SEES teams for collaborations within the research community, and the difference is statistically significant. This suggests that the SEES funding mechanism was particularly effective in creating dynamic networks of interdisciplinary collaborators as measured by the density of ties among experts on all NSF awards won during the full study period. Overall, the SEES funding mechanism was more successful than the non-SEES funding mechanism in attracting investigators from a different discipline. The larger team sizes supported by the SEES funding mechanism seemed to create more opportunity for the inclusion of social scientists and education researchers.
- SEES awards enriched the quality of education in science across all levels—from kindergartners to senior citizens—through a myriad of events for students, totaling over 453 educational-focused products or activities across the country and internationally, including lab tours, science fairs, and the promotion of careers in science. SEES principal investigators (PIs) have published in a large number of multidisciplinary journals. They raised the visibility of and interest in sustainability research as implied by the high citation counts of their publications.

Workshops and Reports:

- The OCE is sponsoring a facilitated workshop in FY 2019 titled “Future of Marine Seismic Capabilities Workshop” to address plans for 3-Dimensional and deep crustal seismic data acquisition for NSF-funded basic research in the marine geosciences after retirement of the NSF-owned Research Vessel *Marcus G. Langseth* in late calendar 2020.

Committees of Visitors (COV):

- In 2018, COVs reviewed Geospace programs in the AGS and the Integrative Programs Section in OCE. The COV reports were presented to the GEO Advisory Committee at their October 2018 meeting. In its report, the COV looking at geospace programs recommended that programs consider sustainability of early career researchers, and recommended that a future COV examine the long-term effectiveness of supporting CubeSats.
- In 2019, COVs will review facilities and infrastructure in AGS and research programs in OCE.
- In 2020, a COV will review lower atmospheric research, infrastructure, and education programs in AGS.

The Performance chapter provides details regarding the periodic reviews of programs and portfolios of programs by external COVs and directorate Advisory Committees. Please see this chapter for additional information.

People Involved in GEO Activities

Number of People Involved in GEO Activities			
	FY 2018	FY 2019	FY 2020
	Actual	(TBD)	Estimate
	Estimate		
Senior Researchers	4,615	-	4,000
Other Professionals	2,758	-	2,400
Postdoctoral Associates	602	-	500
Graduate Students	2,178	-	1,900
Undergraduate Students	2,110	-	1,800
Total Number of People	12,263	-	10,600

DIVISION OF ATMOSPHERIC AND GEOSPACE SCIENCES (AGS)

\$221,970,000
-\$54,130,000 / -19.6%

AGS Funding
(Dollars in Millions)

	FY 2018 Actual	FY 2019 (TBD)	FY 2020 Request	Change over	
				FY 2018 Actual Amount	Percent
Total	\$276.10	-	\$221.97	-\$54.13	-19.6%
Research	116.01	-	96.00	-20.01	-17.2%
CAREER	8.09	-	4.00	-4.09	-50.5%
Education	2.91	-	3.64	0.73	24.9%
Infrastructure	157.18	-	122.33	-34.85	-22.2%
Arctic Logistics	0.78	-	-	-0.78	-100.0%
Arecibo Observatory	5.42	-	2.13	-3.29	-60.7%
NCAR ¹	126.34	-	99.70	-26.64	-21.1%
Research Resources	24.64	-	20.50	-4.14	-16.8%

¹ FY 2018 Actual includes \$26.64 million in additional FY 2018 one-time funding above the requested amount.

About AGS

AGS supports fundamental research activities that lead to improved understanding of the dynamics of the sun, the physics, chemistry, and dynamics of the Earth’s atmosphere and near-space environment, and how the sun interacts with the Earth’s atmosphere. Improved understanding drives state-of-the-science model development and improved predictability of weather, climate, and space weather events. AGS provides support for: (1) basic science projects and (2) the acquisition, maintenance, and operation of observational and cyber-infrastructure facilities and services that enable and support modern-day atmospheric and geospace science research activities. AGS support occurs via the traditional individual investigator merit-reviewed multi-year grants, limited duration exploratory research projects, and collaborative and multi-investigator group projects. In addition, research is conducted using leadership-class facilities provided by the National Center for Atmospheric Research (NCAR). Through improvements to our understanding of severe weather events, and the development of sophisticated computer models that simulate and forecast such events and their impacts, AGS helps protect life, property, and natural resources, and contributes to the establishment of a weather-ready and space weather-ready nation. AGS-supported scientists lead innovations ranging from the miniaturization of sensors that fly on cubesats, to the creation of high-resolution models that enable prediction of a variety of severe weather hazards. AGS also funds STEM education, fosters the success of early career scientists, and supports the continuing development of a world-class scientific and technical workforce that contributes significantly to the nation’s economic vitality.

About 27 percent of the AGS portfolio is available for new research grants. The remainder supports research grants made in prior years and the research infrastructure that supports the capabilities, creativity, and innovation of the atmospheric and geospace science community. AGS frequently participates in major NSF-wide initiatives and long-standing NSF programs, such as the Major Research Instrumentation program. AGS also partners with other programs within GEO, across other NSF directorates, and with other federal agency partners, to help ensure that the most impactful science is being funded.

DIVISION OF EARTH SCIENCES (EAR)

\$156,970,000
-\$22,720,000 / -12.6%

EAR Funding
(Dollars in Millions)

	FY 2018 Actual	FY 2019 (TBD)	FY 2020 Request	Change over	
				FY 2018 Actual Amount	Percent
Total	\$179.69	-	\$156.97	-\$22.72	-12.6%
Research	117.69	-	100.36	-17.33	-14.7%
CAREER	9.34	-	5.99	-3.35	-35.9%
Education	4.97	-	4.51	-0.46	-9.2%
Infrastructure	57.03	-	52.10	-4.93	-8.6%
Geodetic Facility for the Advancement of GEoscience (GAGE)	11.49	-	11.86	0.37	3.2%
National Nanotechnology Coordinated Infrastructure (NNCI)	0.30	-	0.30	-	-
Seismological Facility for the Advancement of GEoscience (SAGE)	23.61	-	21.94	-1.67	-7.1%
Research Resources	21.63	-	18.00	-3.63	-16.8%

About EAR

EAR supports fundamental research into the structure, composition, and evolution of the Earth, and the life it has sustained over the four and a half billion years of Earth history. The results of this research will lead to a better understanding of Earth's changing environment (past, present, and future), the natural distribution of its mineral, water, biota, and energy resources, and provide methods for predicting and mitigating the effects of geologic hazards such as earthquakes, volcanic eruptions, floods, and landslides.

EAR supports research in geomorphology and land use, hydrologic science, geobiology and low temperature geochemistry, sedimentary geology and paleobiology, geophysics, petrology and geochemistry, tectonics, and integrated Earth systems. In addition to these fundamental research programs, EAR has an Instrumentation and Facilities program that supports community-based, shared-use facilities and the acquisition and development of instrumentation by individual investigators; and an education program that funds several activities to attract and support students and young investigators to the field of Earth science.

In general, about 40 percent of the EAR portfolio is available for new research grants. The remaining 60 percent supports research grants made in prior years and the research infrastructure needed by this community.

**DIVISION OF INTEGRATIVE AND COLLABORATIVE
EDUCATION & RESEARCH (ICER)**

\$93,200,000
+\$7,450,000 / 8.7%

ICER Funding
(Dollars in Millions)

	FY 2018 Actual	FY 2019 (TBD)	FY 2020 Request	Change over	
				FY 2018 Actual Amount	Percent
Total	\$85.75	-	\$93.20	\$7.45	8.7%
Research	70.40	-	87.50	17.10	24.3%
Big Idea: NNA	-	-	30.00	30.00	N/A
CAREER	0.40	-	-	-0.40	-100.0%
Education	15.35	-	5.70	-9.65	-62.9%

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 join with other parts of NSF in major integrative research and education efforts. In addition, in partnership with several of the NSF directorates, ICER will advance the NNA Big Idea by investing funds to support convergent activities that transcend the traditional disciplinary boundaries of individual NSF directorates and offices. In FY 2020, the division will make strategic investments in multidisciplinary research areas, international activities, education, diversity, and human resource development. The results of these investments will assist in ensuring that the U.S. has a well-educated and diverse workforce in the geosciences and in related technical fields such as resource exploration. In 2019 several education programs were consolidated into other parts of NSF, which is reflected in the reduction in ICER education support.

In general, about 50 percent of the ICER portfolio is available for new research grants with the remaining amount supporting grants made in prior years.

DIVISION OF OCEAN SCIENCES (OCE)

\$314,910,000
-\$51,350,000 / -14.0%

OCE Funding
(Dollars in Millions)

	FY 2018 Actual	FY 2019 (TBD)	FY 2020 Request	Change over	
				FY 2018 Actual Amount	Percent
Total	\$366.26	-	\$314.91	-\$51.35	-14.0%
Research	168.29	-	143.37	-24.92	-14.8%
CAREER	3.94	-	2.00	-1.94	-49.3%
Centers Funding (total)	5.00	-	1.30	-3.70	-74.0%
STC: Center for Dark Energy Biosphere Investigations	5.00	-	1.30	-3.70	-74.0%
Education	4.93	-	4.84	-0.09	-1.8%
Infrastructure	193.05	-	166.70	-26.35	-13.6%
Academic Research Fleet ¹	86.03	-	74.10	-11.93	-13.9%
Antarctic Facilities & Operations	3.66	-	-	-3.66	-100.0%
International Ocean Discovery Program	47.55	-	45.80	-1.75	-3.7%
Ocean Observatories Initiative	44.08	-	38.00	-6.08	-13.8%
Research Resources	11.72	-	8.80	-2.92	-24.9%

¹ FY 2018 Actual includes \$6.0 million in additional FY 2018 one-time funding above the requested amount.

About OCE

OCE supports interdisciplinary research, education, and cutting-edge infrastructure that advances our scientific knowledge of the oceans to support the U.S. economy over the long term, provides vital information regarding national security matters such as sea level rise, and advances U.S. leadership in ocean science and technological innovation. OCE provides support of basic scientific research and technology development to better understand changing ocean circulation and other physical parameters, biodiversity and the dynamics of marine organisms and ecosystems, and changing ocean chemistry as exemplified by ocean acidification. OCE also supports research on the geology of the ocean margins and sub-seafloor to investigate the occurrence of methane hydrates, natural hazards associated with earthquakes and volcanic eruptions, microbial life deep below the seafloor, and other fundamental ocean processes. Ocean education emphasizes the interdisciplinary nature of ocean sciences, and commonly leverages research facilities and infrastructure via telepresence to far and distant seas. Since 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. Broadly speaking, research, education, and infrastructure funded by OCE addresses the central role of the oceans in a changing Earth and as a national strategic resource, as recognized by numerous reviews by external bodies (e.g., the National Academies Decadal Survey *Sea Change*).

In general, about 34 percent of the OCE portfolio is available for new research grants, with the remainder supporting grants made in prior years and the research infrastructure needed by this community.