

DIRECTORATE FOR GEOSCIENCES (GEO)**\$1,194,920,000**
+\$190,740,000 / 19.0%**GEO Funding¹**
(Dollars in Millions)

	FY 2020 Actual	FY 2021 Estimate	FY 2022 Request	Change over	
				FY 2021 Amount	Estimate Percent
Atmospheric and Geospace Sciences (AGS)	\$280.08	\$283.47	\$341.71	\$58.24	20.5%
Earth Sciences (EAR)	199.21	201.36	240.04	38.68	19.2%
Integrative & Collaborative Education & Research (ICER)	113.07	116.30	137.03	20.73	17.8%
Ocean Sciences (OCE)	401.36	403.05	476.14	73.09	18.1%
Total	\$993.72	\$1,004.18	\$1,194.92	\$190.74	19.0%

¹ Funding for FY 2020 and FY 2021 is adjusted for comparability to reflect the movement of I-Corps™ to TIP in FY 2022. See the R&RA Overview for more details.

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. Home to NSF’s atmospheric and geospace, earth, and ocean research activities and providing coordination and administrative oversight to the Office of Polar Programs, GEO investigates 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. Lives are saved and property is preserved by better forecasting and understanding of natural phenomena and environmental hazards such as earthquakes, tornadoes, drought, and solar storms. GEO prioritizes support for interdisciplinary studies that contribute directly to national research priorities including climate change, racial equity, and recovery from the COVID pandemic.

Support for climate change research and the U.S. Global Change Research Program (USGCRP) is a particular emphasis in FY 2022. Investments are framed around five major themes: Ocean’s Role in Climate Change and Climate Solutions, Terrestrial-Climate Interactions and Water Sustainability, Cryosphere and Climate Change, Forcings and Feedbacks, and Earth System Predictability and Resilience. Crossing climate change themes, a new activity on climate change and social justice will utilize the integrating theme of climate change as the foundation for building diverse and inclusive research ecosystems that also focus on institutional transformation towards inclusivity.

As the lead directorate, GEO is the steward of funds designated for the NSF-wide Big Idea: Navigating the New Arctic (NNA). For more information about the Big Ideas, see the narratives in the NSF-Wide Investments chapter.

GEO strongly supports the concept of racial equity and seeks to encourage the removal of barriers to participation in the geosciences. In FY 2022, a new activity on climate change and racial equity will use the integrating theme of climate change as the foundation for building diverse and inclusive research ecosystems that also focus on institutional transformation towards inclusivity.

GEO provides 57 percent of the federal funding for basic research at academic institutions in the environmental sciences.

Major Investments

GEO Major Investments

(Dollars in Millions)

Area of Investment ^{1,2}	FY 2020	FY 2021	FY 2022	Change over	
	Actual	Estimate	Request	FY 2021 Estimate Amount	Percent
Artificial Intelligence	\$5.00	\$5.00	\$5.00	-	-
Biotechnology	8.00	10.00	10.00	-	-
Climate: USGCRP	294.17	329.23	481.70	152.47	46.3%
Coastlines and People (CoPe)	4.41	15.00	23.00	8.00	53.3%
Improving Undergraduate STEM Education (IUSE)	6.86	8.00	6.00	-2.00	-25.0%
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NSF's Big Ideas					
<i>NNA Stewardship</i>	<i>27.20</i>	<i>30.00</i>	<i>30.00</i>	-	-

¹ Major investments may have funding overlap and thus should not be summed.

² This table reflects this directorate's support for selected areas of investment. In other directorate narratives, areas of investment displayed in this table may differ and thus should not be summed across narratives.

- **Artificial Intelligence:** GEO, in partnership with CISE and other NSF directorates and offices, other federal agencies, and the private sector, will support AI research and development. A key focal point in GEO is support for a set of National AI Research Institutes. These center-scale projects will advance foundational research; leverage use-inspired research; build the next-generation of talent; mobilize multidisciplinary groups of scientists, engineers, and educators; and serve as a nexus point for multisector collaborative efforts.
- **Biotechnology:** GEO, together with other NSF directorates/offices, will invest in fundamental research, infrastructure, and education that advances foundational knowledge needed to understand and harness biological processes for societal benefit.
- **Climate: USGCRP:** GEO leads NSF efforts to support the goals of the USGCRP. In FY 2022, investment is framed around five major themes: Ocean’s Role in Climate Change, Terrestrial-Climate Interactions and Water Sustainability, Cryosphere and Climate Change, Forcings and Feedbacks, and Earth System Predictability.
- **CoPe:** CoPe was a new program in FY 2019 and received broad community interest. Through this program, GEO supports projects to build capacity and better understand the impacts of coastal environmental variability and natural hazards on populated coastal regions. Improved Earth system prediction is a major CoPe objective. Investment in FY 2022 increases in response to the tremendous number of strong proposals received in 2021.
- **IUSE:** Funding for the NSF-wide IUSE activity continues to support development of the next generation of geoscientists. In FY 2021, there was a special emphasis in IUSE related to COVID response and recovery, which has been discontinued for FY 2022.
- **I-Corps™:** In FY 2022, support for I-Corps has been consolidated in the TIP Directorate.
- **NNA:** GEO provides stewardship of the NNA Big Idea. NNA fosters innovations in Arctic observational networks and fundamental convergence research across the social, natural, environmental, and computing and information sciences and engineering that address the intersection of natural, social, and built systems. Improved Earth system prediction is a major NNA objective.

GEO Funding for Centers Programs and Major Facilities

GEO Funding for Centers Programs

(Dollars in Millions)

	FY 2020 Actual	FY 2021 Estimate	FY 2022 Request	Change over FY 2021 Estimate	
				Amount	Percent
Artificial Intelligence Research Institutes	\$5.00	\$5.00	\$5.00	-	-
STC: Center for Dark Energy Biosphere Investigations	1.30	-	-	-	N/A
Total	\$6.30	\$5.00	\$5.00	-	-

GEO will continue support for the AI Research Institute: Artificial Intelligence for Environmental Sciences (AI2ES) in FY 2022. For detailed information on individual centers programs, please see the NSF-Wide Investments chapter.

GEO Funding for Major Facilities

(Dollars in Millions)

	FY 2020 Actual	FY 2021 Estimate	FY 2022 Request	Change over FY 2021 Estimate	
				Amount	Percent
Academic Research Fleet (ARF)	\$105.38	\$107.38	\$117.88	\$10.50	9.8%
Arecibo Observatory (AO)	2.76	12.38	8.00	-4.38	-35.4%
Geodetic Facility for the Advancement of GEoscience (GAGE)	12.37	12.75	12.75	-	-
International Ocean Discovery Program (IODP)	48.00	48.00	48.00	-	-
National Center for Atmospheric Research (NCAR)	99.70	104.00	104.00	-	-
Ocean Observatories Initiative (OOI)	43.97	44.00	48.50	\$4.50	10.2%
Seismological Facility for the Advancement of GEoscience (SAGE)	20.66	21.00	21.00	-	-
Total	\$332.85	\$349.51	\$360.13	\$10.62	3.0%

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

Funding Profile

GEO Funding Profile			
	FY 2020		
	Actual	FY 2021	FY 2022
	Estimate	Estimate	Estimate
Statistics for Competitive Awards:			
Number of Proposals	3,309	3,700	4,200
Number of New Awards	1,359	1,200	1,500
Regular Appropriation	1,359	1,200	1,500
CARES Act	-		
Funding Rate	41%	32%	36%
Statistics for Research Grants:			
Number of Research Grant Proposals	2,968	3,300	3,800
Number of Research Grants	1,152	1,000	1,300
Regular Appropriation	1,152	1,000	1,300
CARES Act	-		
Funding Rate	39%	30%	34%
Median Annualized Award Size	\$162,217	\$152,000	\$175,000
Average Annualized Award Size	\$214,870	\$220,000	\$225,000
Average Award Duration, in years	2.9	3.0	3.0

In FY 2022, the number of research grant proposals is expected to increase by about 850 compared to the FY 2020 Actual, and GEO expects to award about 150 more research grants as grant competitions related to climate change are anticipated. Average annual award size and duration are expected to rise slightly between FY 2020 and FY 2022.

Program Monitoring and Evaluation

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

People Involved in GEO Activities

Number of People Involved in GEO Activities			
	FY 2020		
	Actual	FY 2021	FY 2022
	Estimate	Estimate	Estimate
Senior Researchers	5,304	5,300	6,300
Other Professionals	2,850	2,900	3,300
Postdoctoral Associates	631	600	800
Graduate Students	2,543	2,600	3,000
Undergraduate Students	3,057	3,100	3,600
Total Number of People	14,385	14,500	17,000

DIVISION OF ATMOSPHERIC AND GEOSPACE SCIENCES (AGS)

\$341,710,000
+\$58,240,000 / 20.5%

AGS Funding
(Dollars in Millions)

	FY 2020 Actual	FY 2021 Estimate	FY 2022 Request	Change over FY 2021 Estimate	
				Amount	Percent
Total	\$280.08	\$283.47	\$341.71	\$58.24	20.5%
Research	141.90	135.45	184.97	49.52	36.6%
CAREER	8.90	5.00	10.00	5.00	100.0%
Education	5.18	3.14	3.77	0.63	20.1%
Infrastructure	133.00	144.88	152.97	8.09	5.6%
AO	2.76	12.38	8.00	-4.38	-35.4%
NCAR	99.70	104.00	104.00	-	-
Research Resources	30.54	28.50	40.97	12.47	43.8%

About AGS

AGS supports fundamental research that leads to improved understanding of the physics, chemistry, and dynamics of the Earth’s atmosphere, weather and climate, and how the sun interacts with the Earth’s atmosphere and how the atmosphere interacts with other components of the Earth’s integrated systems. Improved understanding drives state-of-the-science model development and predictability of weather, climate, and space weather events. AGS provides support for: (1) basic science projects and (2) the infrastructure, facilities, and services that enable and support modern-day atmospheric and geospace research activities.

Research supported by AGS directly impacts and improves the lives of Americans. Advances in understanding severe weather events leads to the development and enhancement of the sophisticated computer models that simulate and predict high-impact events e.g., tornados, hurricanes, and drought, which helps protect life, property, natural resources, and contributes to the establishment of a weather-ready nation. AGS also funds related education activities, 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.

AGS supports the research of individual scientists at academic institutions, groups of researchers, and research activities at the National Center for Atmospheric Research (NCAR). Often in partnership with complementary activities at other agencies including NOAA and NASA, research is conducted using world-class facilities provided by NCAR and other groups across the US. AGS supports a neutron monitoring network, providing early warning should there be a large Earth-directed solar flare. AGS-supported scientists lead innovations ranging from development of research instruments, the miniaturization of sensors that fly on CubeSats, to the development of models that provide the scientific basis of forecasting a variety of severe weather hazards and understanding of our climate and space environment.

AGS activities directly support the USGCRP. Enhanced process understanding, both through observational and modeling studies, builds our knowledge base related to climate change. This knowledge is translated into predictive models of future climate scenarios to help inform national and international climate policy. This knowledge has direct applications to society in terms of decision-making and forms the underpinnings of a robust development of the national policy for adaptation and mitigation of climate change.

Directorate for Geosciences

About 35 percent of the AGS portfolio is available for new research grants. The remaining 65 percent 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.

DIVISION OF EARTH SCIENCES (EAR)

240,040,000
+38,680,000 / 19.2%

EAR Funding
(Dollars in Millions)

	FY 2020 Actual	FY 2021 Estimate	FY 2022 Request	Change over FY 2021 Estimate	
				Amount	Percent
Total	\$199.21	\$201.36	\$240.04	\$38.68	19.2%
Research	133.84	134.27	168.51	34.24	25.5%
CAREER	9.99	7.50	9.00	1.50	20.0%
Education	7.17	6.71	7.95	1.24	18.5%
Infrastructure	58.21	60.38	63.58	3.20	5.3%
GAGE	12.37	12.75	12.75	-	-
NNCI	0.40	0.30	0.30	-	-
SAGE	20.66	21.00	21.00	-	-
Research Resources	24.77	26.33	29.53	3.20	12.2%

About EAR

EAR supports fundamental research into the structure and composition of the Earth and the processes that govern it. Research spans from the Earth’s surface to its center, and includes the evolution and history of the Earth, and the life it has sustained over four and a half billion years. This research, as articulated by the National Academies of Science, Engineering and Medicine decadal *Earth in Time* report, is critical for understanding Earth's environment and its impact on society, including its climate (past, present, future), the distribution of its natural resources (mineral, water, biota, and energy), and the fundamental drivers of geologic hazards. EAR research provides predictive and quantitative understanding of earthquakes, volcanic eruptions, floods, landslides, changing climate, natural resources, and the overall Earth system. EAR education and human resources engages a wide range of audiences in Earth Science research efforts and fosters a just, equitable, diverse, and inclusive culture across the geosciences.

EAR’s programs support state-of-the-art science using observational, experimental, theoretical, and computational approaches in scientific domains spanning geobiology and low temperature geochemistry, geomorphology and land-use dynamics, geophysics, hydrology, petrology and geochemistry, sedimentary geology and paleobiology, and tectonics. In addition to these fundamental research programs, EAR supports large-scale community and global efforts, including seismic and geodetic facilities, geohazards centers, and cyberinfrastructure focused on Earth science applications. EAR also supports community-based, shared-use facilities, and the acquisition and development of instrumentation by individual investigators. Integrated research that crosses disciplinary boundaries is supported through division programs as well as partnership with other GEO divisions and directorates. Education and human resource development activities support postdoctoral scientists as well as projects and programs to attract students and young investigators to the field of Earth science.

EAR supports research aligned with USCGRP priorities. Programs support multi-disciplinary, fundamental research on the impacts and feedbacks between climate change and the water cycle, the Earth’s surface and biota, as well as the impacts of climate change on geohealth and extreme events, such as droughts, wildfires, and floods. Research on paleobiology and paleoclimate further the understanding of what the Earth’s past reveals about the dynamics of climate change. The division also supports multidisciplinary research on the “critical zone”, which extends from the top of the vegetation canopy to the base of the weathered rock zone,

including woodland ecosystems. These components of the Earth's life-support system interact through connected processes that influence and are affected by climate, lithology, anthropogenic activity, and water and nutrient cycles. This research is vital to understanding the Earth System and how it has responded, and will respond, to climate change. Contributions to cross-disciplinary Earth observation efforts include: continental drilling infrastructure that forms the basis of collection of records of past climate, providing critical data for predicting modern climate change; integration of atmospheric and Earth surface observations with seismic and geodetic capabilities; and cyberinfrastructure to enable analysis and modeling of terrestrial Earth responses to climate change. Through its community facilities, EAR supports collection of data critical for understanding past, present, and future climate; and the development and dissemination of integrated climate models related to Earth surface processes and the hydrologic cycle. These facilities and models serve the research community at large and further the understanding of the interactions between water, Earth, society, and changing climate.

In general, about 53 percent of the EAR portfolio is available for new research grants. The remaining 47 percent supports research grants made in prior years and the research infrastructure needed by this community.

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

\$137,030,000
+\$20,730,000 / 17.8%

ICER Funding
(Dollars in Millions)

	FY 2020 Actual	FY 2021 Estimate	FY 2022 Request	Change over	
				FY 2021 Estimate Amount	Percent
Total	\$113.07	\$116.30	\$137.03	\$20.73	17.8%
Research	105.00	116.30	137.03	20.73	17.8%
CAREER	0.15	-	-	-	N/A
Centers Funding (total)	5.00	5.00	5.00	-	-
Artificial Intelligence Research Institutes	5.00	5.00	5.00	-	-
Education	4.70	-	-	-	N/A
Infrastructure	3.36	-	-	-	N/A
ARF	3.36	-	-	-	N/A

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 Ideas by investing funds to support convergent activities that transcend the traditional disciplinary boundaries of individual NSF directorates and offices. In FY 2021, the division will make strategic investments in multidisciplinary research areas, international activities, education, diversity, and human resource development. A continuing emphasis in FY 2021 is Coastlines and People (CoPe), which supports research focused on understanding the impacts of coastal environmental variability and natural hazards on populated coastal regions. The results of ICER 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.

Numerous ICER activities directly support the USGCRP. The NNA Big Idea focuses on the impacts of Arctic change and the NSF-wide Coastlines and People program, which is primarily supported in ICER, examines the impacts of climate on coastal regions in order to improve human and community resilience to climate change. In addition, ICER supports international collaborative activities which focus on climate change.

In general, about 57 percent of the ICER portfolio is available for new research grants with the remaining 43 percent supporting grants made in prior years.

DIVISION OF OCEAN SCIENCES (OCE)

\$476,140,000
+\$73,090,000 / 18.1%

OCE Funding
(Dollars in Millions)

	FY 2020	FY 2021	FY 2022	Change over	
	Actual	Estimate	Request	FY 2021 Estimate	Percent
Total	\$401.36	\$403.05	\$476.14	\$73.09	18.1%
Research	183.23	184.54	238.63	54.09	29.3%
CAREER	5.06	2.00	2.50	0.50	25.0%
Centers Funding (total)	1.30	-	-	-	N/A
STC: Center for Dark Energy Biosphere Investigations	1.30	-	-	-	N/A
Education	5.24	9.13	11.13	2.00	21.9%
Infrastructure	212.89	209.38	226.38	17.00	8.1%
ARF	102.02	107.38	117.88	10.50	9.8%
IODP	48.00	48.00	48.00	-	-
OOI	43.97	44.00	48.50	4.50	10.2%
Research Resources	18.90	10.00	12.00	2.00	20.0%

About OCE

OCE supports cutting-edge research, education, and infrastructure that advances the Nation’s 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 supports basic research, including interdisciplinary scientific research and technology development to better understand the drivers of ocean circulation and other physical and chemical parameters, biodiversity and the dynamics of marine organisms and ecosystems, harmful algal blooms, and changes in the marine environment as exemplified by ocean acidification. OCE also supports research on the geology and geophysics of the ocean margins and sub-seafloor to investigate natural hazards such as earthquakes and volcanic eruptions, nearshore processes affecting the coasts, the long-term evolution of marine systems, 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. Examples include the Ocean Observatories Initiative (OOI) network, the Global Ocean Biogeochemistry Array (GO-BGC) Project, and the Academic Research Fleet (ARF), including the Regional Class Research Vessels (RCRV). OCE-funded research, education, and infrastructure addresses the oceans’ central role in a changing Earth and as a national strategic resource, as recognized in reviews by external bodies (e.g., the National Academies Decadal Survey Sea Change). OCE is participating in the United Nations Decade of Ocean Science (2021-2030), through the U.S. National Committee for the Decade, to help ensure sustainable use of ocean resources and long-term ocean health.

OCE supports USGCRP with investments in science and infrastructure programs that focus on observing today’s changing ocean and facilitating discoveries of past climate changes to inform future climate change. In addition to OOI, examples include the International Ocean Discovery Program (IODP), Long-Term Ecological Research (LTER), Hawaii Ocean Time-series (HOT), Bermuda Atlantic Time-series Study (BATS), Overturning in the Subpolar North Atlantic Program (O-SNAP), and the Paleo Perspectives on

Climate Change (P2C2) Program. OCE has strong representation on the USGCRP Observations Interagency Working Group and the reinvigorated Coasts Focus Area.

In general, about 30 percent of the OCE portfolio is available for new research grants, with the remaining 70 percent supporting grants made in prior years and the research infrastructure needed by this community.

