

NATIONAL SOLAR OBSERVATORY (NSO)

\$25,460,000
\$3,370,000 / 15.3%

National Solar Observatory Funding¹

(Dollars in Millions)

FY 2020	FY 2021	FY 2022	Change over	
			FY 2021 Estimate	
Actual	Estimate ²	Request	Amount	Percent
\$21.79	\$22.09	\$25.46	\$3.37	15.3%

¹ Includes operations for NSO and DKIST.

² Excludes \$2.0 million for cultural mitigation activities as agreed to during the compliance process for DKIST.

Brief Description

As a Federally Funded Research and Development Center, NSO is NSF’s central institution for support of ground-based solar astronomy in the United States. Headquartered on the campus of the University of Colorado, Boulder, NSO provides leadership to the global solar astronomy community through management of the construction of the Daniel K. Inouye Solar Telescope (DKIST; see narrative in the MREFC chapter) as well as its subsequent operation once completed in 2021. DKIST will be the largest and most advanced solar telescope on the planet, poised to answer fundamental questions in solar physics by providing transformative improvements over current ground-based facilities.

NSO also operates the NSO Integrated Synoptic Program (NISP), which consists of the Global Oscillations Network Group (GONG) facility and the Synoptic Long-term Investigations of the Sun (SOLIS) telescope. GONG is a coordinated worldwide network of six telescopes specifically designed to study solar oscillations and, more recently, to provide critical data products for the prediction of space weather. NSO routinely provides detailed synoptic solar data from the NISP program for use by individual researchers and other government agencies through the NSO Digital Library.

Scientific Purpose

The mission of NSO is to advance our knowledge of the Sun, both as an astronomical object and as the dominant external influence on the Earth, by providing forefront observational capabilities to the scientific research community. NSO operates a diverse fleet of ground-based optical and infrared solar telescopes and auxiliary instrumentation, allowing solar physicists to probe all aspects of the Sun, from the deep solar interior to the photosphere and chromosphere, to the outer corona and its interface with the interplanetary medium.

DKIST will enable the study of magnetic phenomena in the solar photosphere, chromosphere, and corona. Determining the role of magnetic fields in the outer regions of the Sun is crucial to understanding the solar dynamo, solar variability, and solar activity including flares and coronal mass ejections, and the impact on planets. Solar activity can affect civil life on Earth through phenomena generally described as space weather and may impact the terrestrial climate.

Other NSO assets also provide data to space weather researchers in their efforts to understand solar eruptions and their effect upon the Earth and to apply that knowledge to the protection of satellites, astronauts, land-based power systems, and Earth's climate. GONG operations are a critical element of operational space weather prediction and provide data enabling refinement of forecasting models for solar activity.

Status of the Facility

NSO also provides site infrastructure support at the Sunspot Solar Observatory (formerly Sacramento Peak Observatory) to New Mexico State University (NMSU), which is responsible for the science operations of the Dunn Solar Telescope. NSO has been in the process of transitioning away from its two primary user facilities at Kitt Peak, Arizona and Sacramento Peak, New Mexico, which began operations in 1962 and 1969, respectively. Although these two sites were once the best ground-based facilities available to the U.S. solar research community on a peer-reviewed proposal basis, there are currently better ground-based facilities both inside and outside the United States. As of January 2019, NSO has vacated its site at the Kitt Peak National Observatory (KPNO). The remaining building there is currently operated by NSF's National Optical-Infrared Astronomy Research Laboratory (NOIRLab; see NOIRLab narrative for more information). NISP's SOLIS telescope was removed from KPNO and is being relocated to Big Bear, California. The construction related to this relocation has been delayed due to COVID-19 but is expected to begin in Q3 of FY 2021

Due to COVID-19, on March 17, 2020, all work-related travel ceased, and the observatory initiated 100% telework at all NSO sites to comply with stay-at-home orders issued by the governors of Colorado, New Mexico, and Hawaii. Since late October 2020, NSO headquarters in Boulder, Colorado has been operating under Phase 1 of their operations restart plan. Phase 1 includes telework for non-essential employees. Only essential workers are allowed on site with safety measures in place. The GONG facility is operational, and DKIST construction is in a modified Phase 1, as discussed in the DKIST narrative in the MREFC chapter. GONG sites are operated remotely and were minimally impacted by COVID-19 shutdowns. Sunspot Solar Observatory is operational under a similar Phase 1 status.

Meeting Intellectual Community Needs

NSO data, including NISP data, are made available to the user community via the Virtual Solar Observatory. DKIST data will be available via the DKIST Data Center located at NSO's Boulder headquarters. The relevance of DKIST's science drivers was reaffirmed by the National Academy of Sciences, Engineering, and Medicine's 2010 Astronomy and Astrophysics Decadal Survey: *New Worlds, New Horizons in Astronomy and Astrophysics*¹ as well as the 2012 Solar and Space Physics Decadal Survey: *A Science for a Technological Society*.² Both reports identified the completion of DKIST as a priority for the solar research community.

Governance Structure and Partnerships

NSF Governance Structure

NSF oversight of NSO and DKIST is handled by two program officers (one for NSO operations, and one specifically for DKIST until the construction project is completed) in the MPS Division of Astronomical Sciences (AST). The program officers work cooperatively with staff from MPS, the Office of the General Counsel, and the Office of Legislative and Public Affairs. Within NSF's Office of Budget, Finance and Award Management, the Large Facilities Office provides advice to program staff and assists with agency oversight and assurance. Representatives from some of the above NSF offices comprise the NSO Integrated Program Team, which meets on a semi-annual basis to discuss outstanding program issues. The MPS Facilities team and the NSF Chief Officer for Research Facilities also provide high-level guidance, support, and oversight. Information on oversight of the DKIST Construction Project can be found in the DKIST narrative in the MREFC chapter.

¹ www.nap.edu/catalog/12951/new-worlds-new-horizons-in-astronomy-and-astrophysics

² www.nap.edu/catalog/13060/solar-and-space-physics-a-science-for-a-technological-society

External Governance Structure

NSO is managed by the Association of Universities for Research in Astronomy Inc. (AURA), which comprises 47 U.S. member institutions and three international affiliate members. The NSO director reports to the president of AURA, who is the principal investigator on the current cooperative agreement with NSF. AURA receives management advice from its Solar Observatory Council, composed of members of its scientific and management communities. NSO utilizes a Users’ Committee for the purposes of self-evaluation and prioritization. The Users Committee, composed of scientists with considerable experience with the observatory, reviews for the NSO director all aspects of NSO that affect user experiences. Both NSF program officers for NSO have frequent (at least weekly) discussions and interactions with NSO management, especially the NSO Director. In addition to NSF reviews of the project, the program officers attend the semi-annual meetings of the Solar Observatory Council and the periodic Users Committee meetings as ex officio observers. The program officers conduct periodic site visits to NSO facilities and attend community science meetings to keep abreast of the latest happenings in the solar community.

Partnerships and Other Funding Sources

NSO partners include the National Oceanic and Atmospheric Administration (NOAA), the National Aeronautics and Space Administration (NASA), industrial entities, and universities and institutes that collaborate with NSO on solar instrumentation development. NOAA contributes approximately \$1 million per year to GONG operations under an interagency agreement with NSF. NMSU operates the Dunn Solar Telescope at Sunspot Solar Observatory through a consortium of universities, while NSO continues to maintain the site infrastructure. NSO has partnered with Big Bear Solar Observatory to operate the SOLIS facility once it is installed in Big Bear, California.

Funding

NSF identified a total planning budget of roughly \$202 million for NSO O&M over the 10-year term of the renewed NSO cooperative agreement, June 1, 2015 – Sept. 30, 2024. This includes DKIST operations but does not include the cost of DKIST construction. This also does not include the costs associated with the transition of former NSO facilities on Sacramento Peak and Kitt Peak. The budget projections for FY 2022 and beyond have been slightly increased from prior projections because of NSO’s comprehensive midterm review (see Reviews section), which identified potential budget shortfalls over the remainder of the current award period.

Total Obligations for NSO
(Dollars in Millions)

	FY 2020	FY 2021	FY 2022	ESTIMATES ¹				
	Actual	Estimate	Request	FY 2023	FY 2024	FY 2025	FY 2026	FY 2027
NSO Operations & Maintenance ²	\$4.78	\$4.55	\$5.88	\$6.06	\$6.24	\$6.24	\$6.24	\$6.24
DKIST Operations ³	17.01	17.54	19.58	20.68	21.30	21.30	21.30	21.30
Total	\$21.79	\$22.09	\$25.46	\$26.74	\$27.54	\$27.54	\$27.54	\$27.54

¹ Outyear funding estimates are for planning purposes only. The current cooperative agreement ends September 2024.

² Includes funding for transition activities at Sacramento Peak Observatory in FY 2020 and FY 2021.

³ FY 2021 Estimate excludes \$2.0 million to another awardee for cultural mitigation activities as agreed to during the compliance process.

The total NSF obligations for NSO include additional funding in the form of supplements for work performed under the operations award, including an ongoing supplement (FY 2018-FY 2021) for about \$300,000 per year to maintain the infrastructure at Sacramento Peak in collaboration with NMSU.

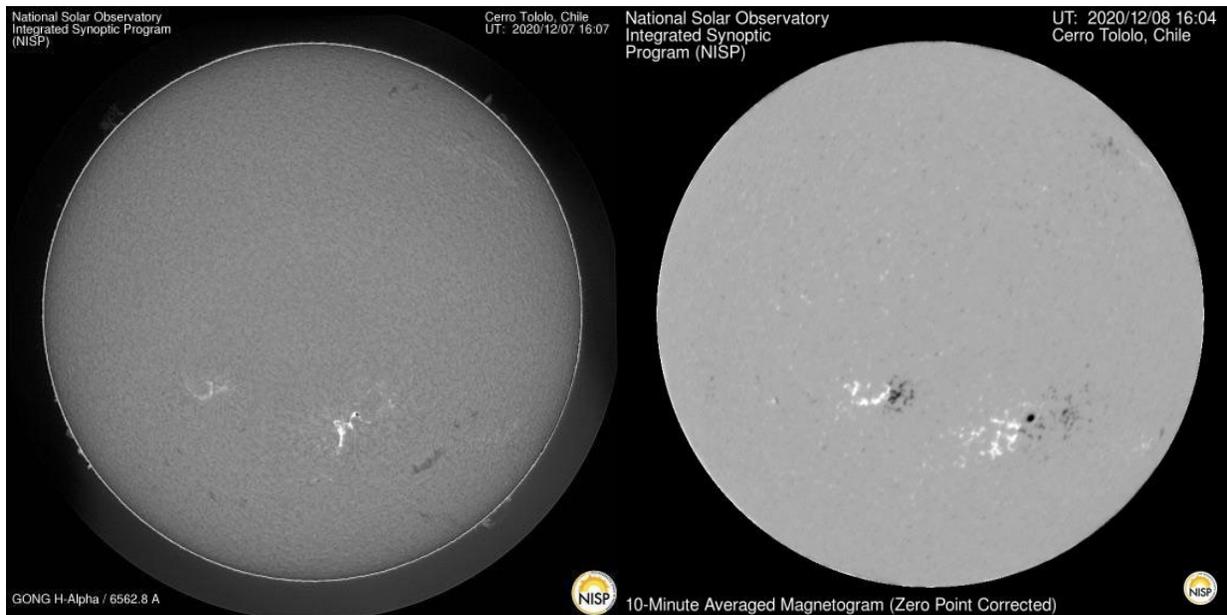
Reviews

- NSF conducts regular reviews of NSO’s Annual Progress Report and Program Plan (APRPP). A review of the current (FY 2020-FY 2021) APRPP was held virtually on April 8, 2021.
- In July 2019, a comprehensive midterm review of NSO’s midterm progress report and long-range plan for the second five years of the cooperative agreement was conducted. The results of this review were presented to the NSB in February 2020.
- NSO participates in reviews of the DKIST construction project, as detailed in the DKIST narrative in the MREFC chapter.

Renewal/Recompetition/Termination

The National Science Board approved the renewal of the NSO/DKIST cooperative agreement in August 2014. The renewed award for management and operations of NSO began June 1, 2015 and will run through September 30, 2024. In order to prepare for a potential two-year re-competition process, in mid-2022, NSF will evaluate the current status of NSO operations and the performance of the managing organization, AURA. The goal will be to determine whether to begin a re-competition of the award for management and operations of the NSO in accordance with NSF policy.

The NSF-NSO-NMSU partnership has resulted in partial operation of the Dunn Solar Telescope and the Visitor Center at NSO’s Sacramento Peak Observatory in Sunspot, New Mexico as part of the divestment of operations costs of that facility. As part of the transition of NSO infrastructure, the McMath-Pierce Solar Telescope facility on Kitt Peak is being converted to an education and outreach center by AURA under an award to NOIRLab (see NOIRLab narrative).



Sample images produced by the GONG facility. Sample H α image (left) and 10-minute average longitudinal magnetogram (right) from Cerro Tololo GONG station on 8 December 2020. Images show a two-ribbon flare (X-ray class C7.4) in the new solar cycle (Cycle 25) active region AR 12790. Credit: NSF/AURA/NSO/NISP.