OpenSpace

2024 Annual Progress Report

NASA SMD Science Activation Program

American Museum of Natural History
200 Central Park West
New York, NY 10024
OpenSpaceProject.com

NASA Partner

Matt Shanley/© AMNH

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I. Administrative

Name and address of the recipient's institution & Cooperative Agreement Number

American Museum of Natural History
200 Central Park West
New York, NY 10024
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Name of the Principal Investigator

Dr. Rosamond Kinzler

Cooperative Agreement Title

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Type of Report

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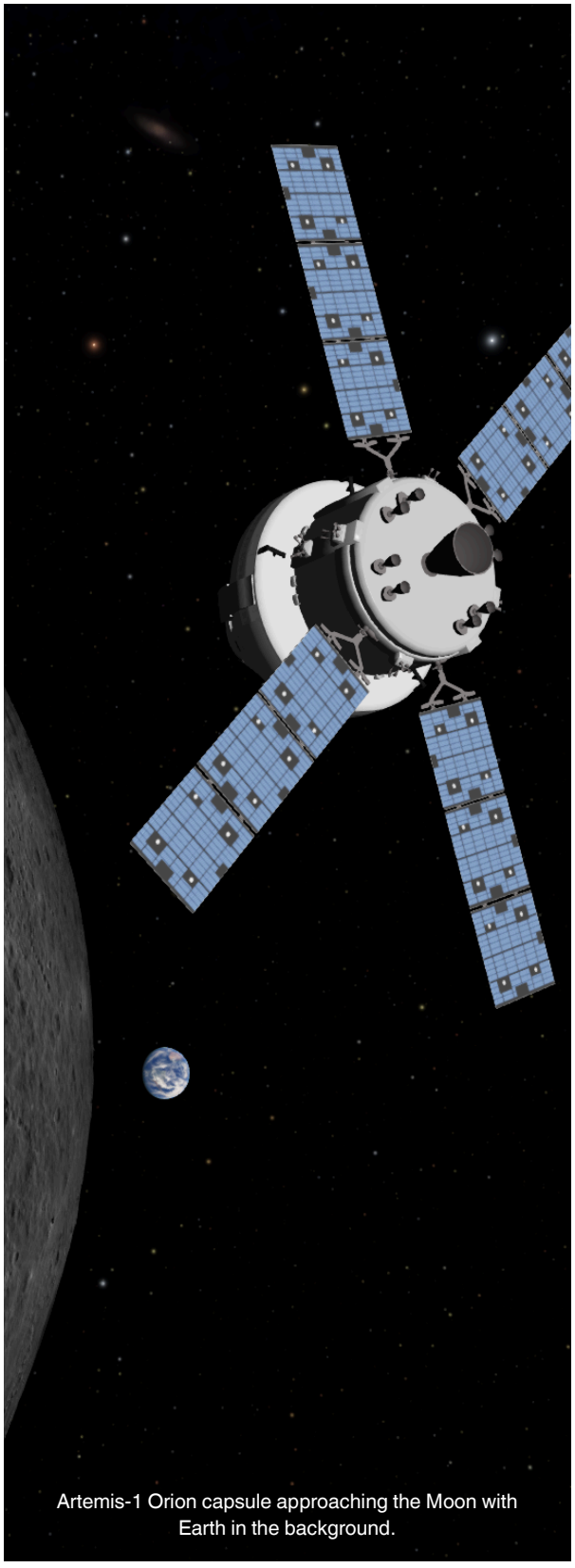


Artemis-1 Orion capsule approaching the Moon with Earth in the background.

II. Accomplishments

The American Museum of Natural History (AMNH) is pleased to submit its ninth yearly update concerning the achievements of *OpenSpace: An Engine for Dynamic Visualization of Earth and Space Science for Informal Education and Beyond*. The primary mission of the OpenSpace project is to create and foster a pipeline that conveys visualized science data from various NASA SMD divisions to Informal Science Institutions (ISIs) and the wider public. A crucial element of this mission is the creation of the open-source software called OpenSpace, along with advocacy for its use in non-formal educational environments through a collaboration with a range of ISI partners.

In the ninth year of the project, AMNH made significant progress toward these goals through ongoing code improvements, new content, enhanced visualizations, public presentations, and active community engagement. A detailed overview of our Year Nine activities is provided below.

Software Development

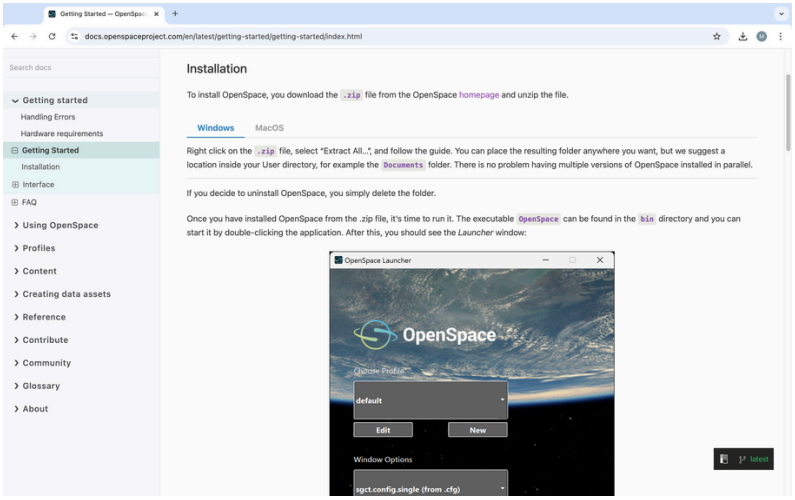
The OpenSpace software has continued to improve in Year Nine through cooperative development at AMNH, Linköping University and Norrköping Visualization Center C,[1] New York University Tandon School of Engineering, and the University of Utah Scientific Computing and Imaging (SCI) Institute. Faculty, software engineers, and graduate research associates at each of these locations have worked together to improve the software by developing efficient code and algorithms to manage data-intensive tasks, integrate new data sets from NASA and other sources, and enhance the user interface.

During this period, OpenSpace had one major software release: Beta-13 (v0.20.0), which was launched on June 17, 2024. Additionally, a minor release, Beta-13 (v0.20.1), followed on July 18, 2024. Full changelogs can be found in *Section IX*.

[1] The activities at Linköping University are not funded by this grant, but are supported by the Knut & Alice Wallenberg Foundation, the Swedish Research Council (Vetenskapsrådet), and the Swedish e-Science Research Centre.

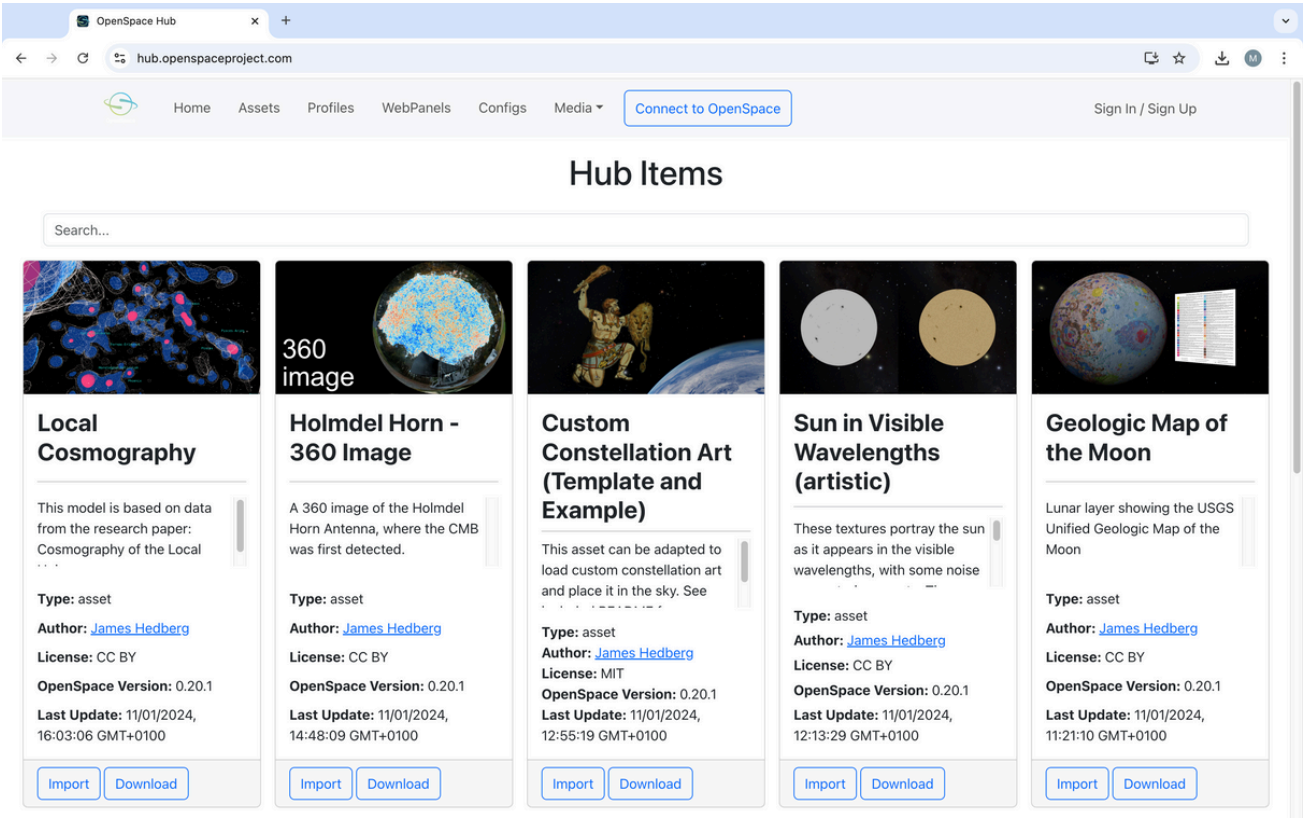
Major new features and computational improvements include:

- *Audio Support:* This feature allows the playback of local MP3 files marking a significant update to the software's capabilities. Users can now play audio in their visual presentations, potentially broadening access to the content and improving the quality of the experience
- *User Settings Storage*: This update allows users to save preferences such as reusing window configuration, profile selection, and caching settings. The feature includes a new user interface for managing these settings through the software's launcher (start-up menu). This update simplifies customization and improves user experience by ensuring configurations persist across sessions, streamlining workflows for frequent users. Additionally, it includes the option to bypass the launcher for quicker access.
- *Point Cloud Overhaul:* A complete overhaul of the point cloud rendering system was implemented, allowing for better performance and more intuitive scaling, especially in multi-projector setups. New features include the ability to load labels from CSV files, interpolate point data over time, add customizable outlines to points, and apply individual textures based on data values. Additionally, texture compression options were added to reduce memory usage, and support for orientation data has been introduced, enabling more detailed and dynamic visualizations. These changes make it much easier for SMEs to include their own datasets into public presentations and thus make them available to the general public.
- *Documentation Revamp*: The OpenSpace documentation was significantly restructured, with all static information moved from the project's documentation folder to the "Reference" section of the official documentation website (https://docs.openspaceproject.com). This reorganization enhances accessibility and user experience by centralizing key resources in a more intuitive online format, making it easier for users to find essential reference materials. The improved website also supports the project's ongoing commitment to clear, accessible, and up-to-date documentation for both new and experienced users.



The Installation page on OpenSpace Docs website.

- *MPCDI Format Support:* Improved the support for the Multiple Projector Common Data Interchange (MPCDI) format, which enhances the software's compatibility with COSM/E&S projection systems.
- *OpenSpace Hub*: The OpenSpace Content Hub (https://hub.openspaceproject.com) was relaunched to allow users to upload their own assets, user profiles, session recordings, and more. Previously, users had to share content with an OpenSpace team member for uploading new content. The new hub serves as a central space for users to contribute and discover new visualizations, fostering collaboration within the community.



The OpenSpace Hub features content uploaded by users.

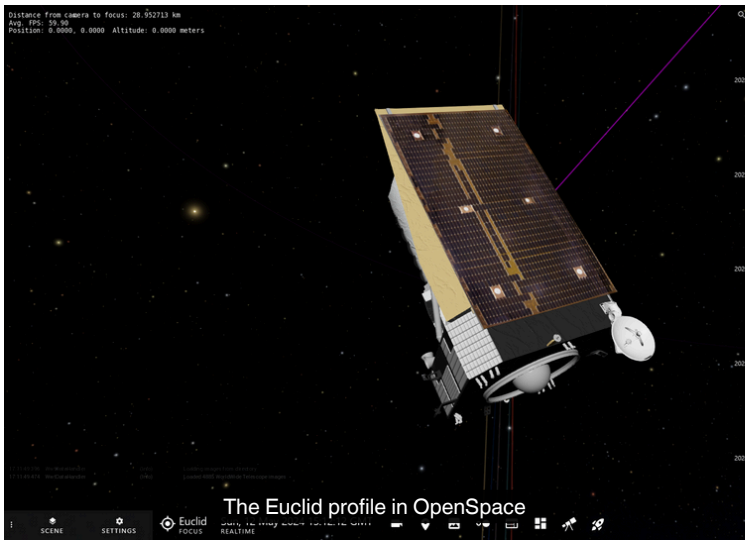
Content Development

The development of new content is continually influenced by our users' needs and feedback and is enriched through partnerships with NASA agencies and infrastructure, along with external scientists and institutions, as detailed below.

OpenSpace currently offers 25 preset profiles. This year we have introduced two new profiles and made improvements to several existing ones.

New Profiles

- *Euclid*: This profile visualizes ESA's Euclid mission which is focused on understanding the universe's structure and the nature of dark energy.
- *BepiColombo*: This profile visualizes ESA's BepiColombo mission which is studying Mercury.



The Euclid profile in OpenSpace

Enhanced Content for Existing Profiles

New Assets

- Big Dipper Constellations
- Tiangong space station
- Historical epicycle concept
- Temporal map layer presenting imagery from the VIIRS instrument on NOAA21
- New map layer showing the last 5,000 years of eclipses

NASA content featured in Public Programs

- Capstone Lunar Orbiter Trajectory
- Custom Constellation Art (Template and Example)
- Europa Clipper mission
- Holmdel Horn - 360 Image
- Map of Europa from Galileo spacecraft
- MilkyWay 3D datasets — Radcliffe wave, Local Bubble
- Saturn V and space shuttle 3D models
- Sun in Visible Wavelengths (artistic images)
- TESS data
- Updated Parker Solar Probe profile
- USGS Unified Geologic Map of the Moon

Accessibility

A main focus of the OpenSpace SciAct 2.0 project has been to improve the user experience. This work extends across several core areas, including the development of OpenSpace Cloud, enhancements to the user interface, and advancements in sonification.

OpenSpace Cloud

Developers at the University of Utah and NYU have been working on the OpenSpace Cloud project, which will enable users to access an OpenSpace instance through a server, eliminating the need for high-end hardware to run the software. A functional interface is in place, and the system is currently running on local servers and through Amazon Web Services. Use case partners, including the B612 Foundation, Cosmic Storytelling with NASA Data, and the Community Coordinated Modeling Center at NASA Goddard, have been confirmed and they will start using OpenSpace Cloud in early 2025, providing valuable feedback on their experiences.

User Interface

In Year Nine, we continued to implement the recommendations we received from Prime Access Consulting (PAC) last year. Prime Access Consulting specializes in accessibility and inclusive design and has supported the OpenSpace team to pinpoint the most urgent areas for accessibility. After reviewing OpenSpace version 0.18.2 in Year Eight, the team at PAC shared two recommendation reports for the software's user interface and launcher. OpenSpace developers have implemented recommendations focused on allowing OpenSpace to run using screen readers.

Sonification

OpenSpace developers have built on previous sonification efforts (Elmquist et al.[2]) through collaboration with researchers to create spatial sonification of data from NASA's Magnetospheric Multiscale (MMS) mission using OpenSpace and SuperCollider.[3] This approach allows each audio stream to be associated with its respective spacecraft, enabling users to experience sonification with spatial accuracy over a flexible timescale. Through this work, a collaboration has emerged with Dr. Kristina Collins, Space Science Institute, and discussions are underway about seeking support through a ROSES grant to continue this work.

[2] E. Elmquist, M. Ejdbo, A. Bock, D. S. Thaler, A. Ynnerman, N. Rönnberg (2024). *Birdsongification: Contextual and complementary sonification for biology visualization*, Proceedings of the 29th International Conference on Auditory Display ICAD.

[3] E. Elmquist, M. Ejdbo, R. Alexander, K. Collins, T. Costello, E. Masongsong (2024). *Demo of Spatial Audification in OpenSpace: MMS Mission.* Zenodo. https://doi.org/10.5281/zenodo.13935818

Stakeholder Meetings

Throughout Year Nine, several meetings were held involving OpenSpace stakeholders.

Developer Meetings

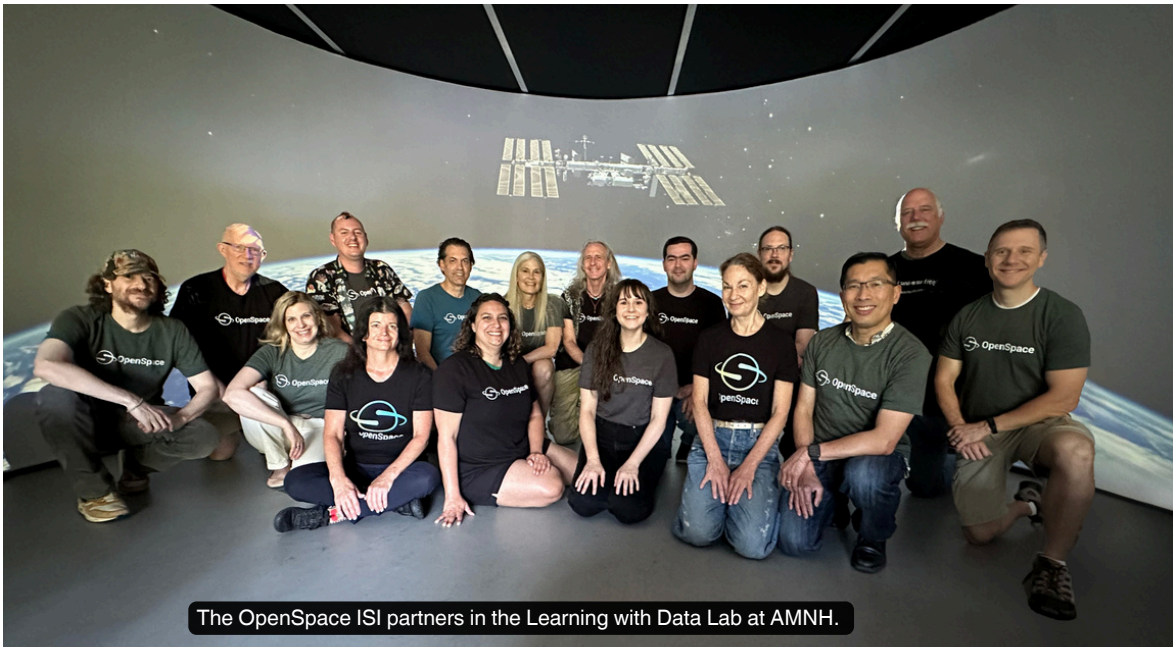
Developers convened for a week of in-person discussions and documentation writing over April 10–15 in Linköping, Sweden. Project leads from AMNH, Linköping University, New York University, and the University of Utah joined for a virtual all team meeting on April 15. This meeting focused on determining development objectives for the remainder of the 2.0 grant. Details of this meeting can be found in Appendix C. The team focused on improvements in the code and documentation that would broaden participation in the project by making it easier to install the software on a variety of systems, improve the user experience, and enable users to share assets, data sets, program guides and other media. This is in line with the “mantras” established at the prior year’s meeting to help guide development through Year Ten of the project:

- "Developers don’t create the majority of content"
- “People should be able to share content without us involved”
- "The average user/builder doesn’t need to touch text files"
- "The average dome technician doesn't need to contact us"
- "Training by OpenSpace team members is not necessary"
- "Bugs and breaks are well documented and communicated to users”

OpenSpace developers discuss example files during the 2024 Developer Meeting in Linköping, Sweden.

Informal Science Institution (ISI) Network

Our annual ISI Network meeting was held at AMNH on June 24–25, bringing together partners from the six funded ISI institutions, along with project evaluators and developers. This event provided a platform for sharing innovative software applications and fostered direct feedback between ISI superusers and the software development team. A key focus of the meeting was discussion of how our funded partners are integrating OpenSpace programming in their institutions' existing outreach to underrepresented groups in STEM and how they are expanding their work in this area. The agenda for this meeting is found in *Appendix C*.



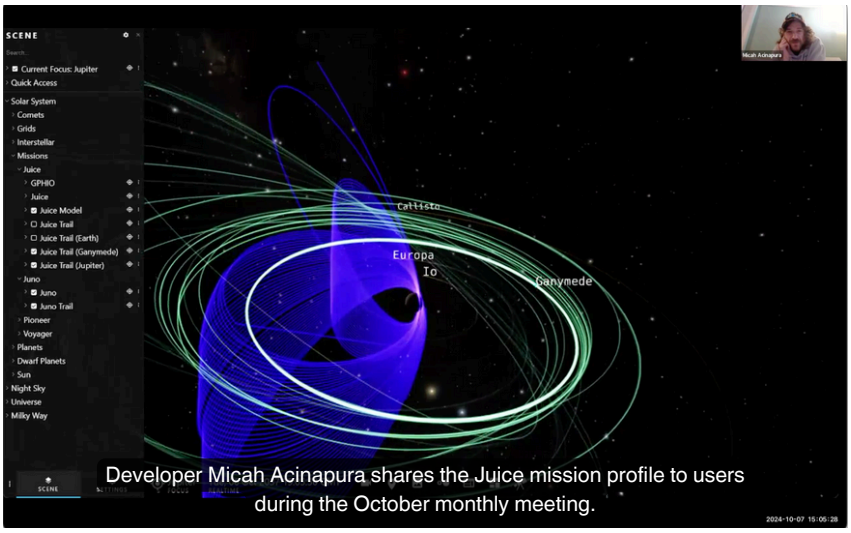
The OpenSpace ISI partners in the Learning with Data Lab at AMNH.

OpenSpace Trainings

Hands-on training sessions continue to be instrumental in developing the skills of OpenSpace users. Through the online booking page (https://calendly.com/openspaceproject/openspace-support), Micah Acinapura, software developer at AMNH, has offered impromptu training sessions and support when requested. During Year Nine this booking page has accounted for 27 sessions spanning 13 different institutions.

An introductory training for New York City-area developers was offered on how to contribute to the software's codebase and content. Five professional developers attended, each having their own area of interest. One has focused on testing the Mac operating system and another collaborated with Dr. Jackie Faherty to add new texture maps to exoplanets. These were used in a public program at the AMNH Hayden Planetarium. More sessions with developers are planned in 2025 to continue to support our open-source ecosystem.

In addition, we continued "OpenSpace Community Monthlies" to share updates with all OpenSpace users, from novice to expert level. This group has become an important source of feedback before and after software releases with attendances ranging from 5 to 20 people. Making these sessions available as a video-on-demand furthermore increases the reach of these community-building events.



Developer Micah Acinapura shares the Juice mission profile to users during the October monthly meeting.

ISI Partner Network Activities

Adler Planetarium

This year, the Adler Planetarium engaged both the public and professionals through exhibitions, theater experiences, and online programs. Additionally, it expanded the use of OpenSpace in online content, exhibitions, and its publicly-accessible Space Visualization Lab, reaching over **900** visitors onsite and **6,000** participants online.

Content development was completed for the new major exhibition *Other Worlds*, which highlights advances in knowledge about planets and exoplanets. One element of the exhibition is an interactive station explaining habitable zones around stars. OpenSpace visuals depict types of planetary bodies within and outside this zone. Another section includes a cart-based activity station for presenting educational activities about planetary science that will be used in future educational programs to show OpenSpace visuals of Mars and other solar system bodies. *Other Worlds* opened in August 2024.

OpenSpace was used in an innovative collaboration with the Chicago Symphony Orchestra (CSO). The Adler worked together with CSO to develop a public program as part of a performance of Holst's The Planets. A series of videos depicting planets in OpenSpace accompanied each piece. Over 300 people attended the sold out performance. Hundreds of people attended informal talks by Lauren Corlies, Data Visualization Engineer, before and during intermission.

Mars visuals and description accompanied the Chicago Orchestra's performance of Holst's The Planets.

The Adler developed several programs for the solar eclipse on April 8, 2024. An onsite event in Chicago to view the partial eclipse attracted about 20,000 people. Several Adler team members led onsite and online programs from the path of totality in Carbondale, IL. As part of the onsite eclipse experience in Chicago, OpenSpace visuals were developed to illustrate the periodic alignment of Earth, moon, and Sun that results in a solar eclipse. These visuals were displayed in the Space Visualization Lab and one other exhibition area, reaching 600 people.

The Adler's onsite outreach program Astronomy Conversations launched in Year Nine. This program allows the public to interact with professional astronomers in the Space Visualization Lab on the lower level of the Adler. The Astronomy team at the Adler is collaborating with dozens of astronomy and astrophysics graduate students from University of Chicago, Northwestern University, and other institutions. They are serving as volunteer experts on astronomy topics during public hours. The Adler is developing strategies for engaging more members of the public in OpenSpace, e.g. simple button controls for controlling OpenSpace within narrative layouts were developed last year that enable Adler guests to interact with OpenSpace content.

In October, the Adler Planetarium hosted a special event for attendees of the Association of Science and Technology Centers (ASTC) 2024 conference. The event featured a presentation by Dr. Rachel Smith from the North Carolina Museum of Natural Sciences and Micah Acinapura, OpenSpace Software Integration Engineer, showcasing how planetariums can utilize the diverse data sets in OpenSpace. The session was attended by 35 science museum professionals.

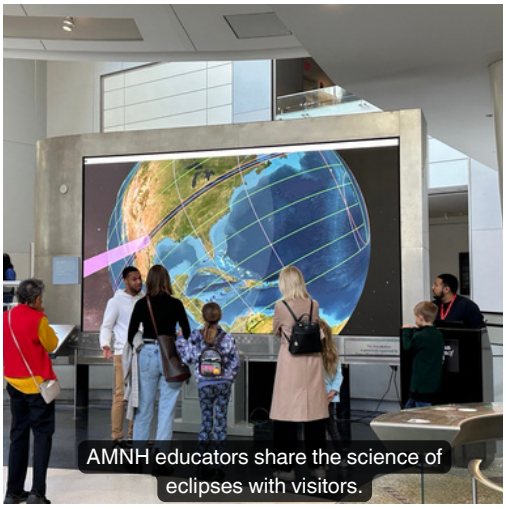
Finally, the Adler continued to share and develop content for digital online outreach. Six online videos featuring OpenSpace have been highlighted on Adler's social media channels and attracted a total of approximately 6,000 views on YouTube.


Joel Hurowitz presents on Perseverance in the Hayden Planetarium.

American Museum of Natural History (AMNH)

OpenSpace users at AMNH continued to grow and use the software in the planetarium, exhibition hall, classroom, and beyond reaching **20,357** people onsite.

Monthly public programs continued in the Hayden Planetarium to explore topics related to Earth and space science in OpenSpace. The family friendly "Astronomy Live" programs showcased a range of topics from Indigenous Astronomy to The Performance of JWST. The more science-focused "Frontiers Lectures" invited Subject Matter Experts to share breaking science with adults in programs like Robotic Mission to Mars and Space Weather.


AMNH educators share the science of eclipses with visitors.

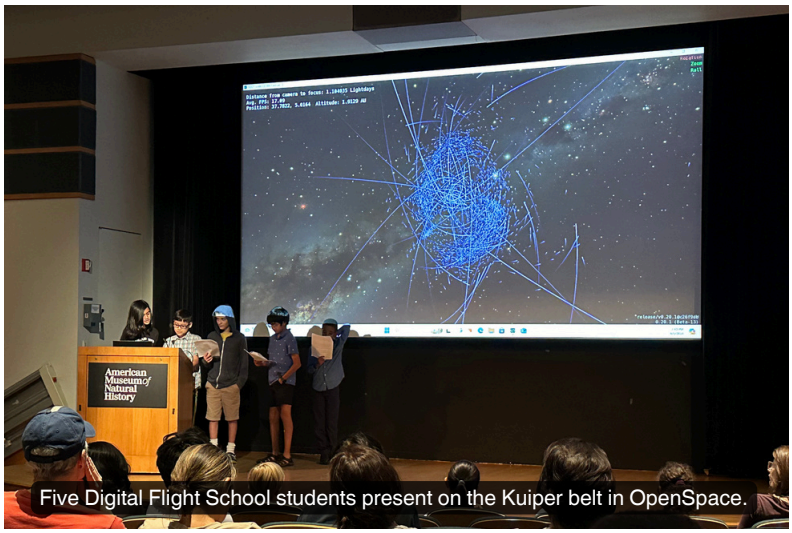
The museum hosted Eclipse Day to celebrate the Total Solar Eclipse. Events included eclipse viewing on the museum terrace as well as stations hosted by educators sharing hands-on activities about the science behind eclipses. Educators presented OpenSpace in the Hall of the Universe to a total of over 14,000 people.

In addition to public programs, OpenSpace was used in internships, pre-service teacher preparation, exhibition content, and other education programs:


Jackie Faherty presents Manhattanhenge using OpenSpace in the 3D.

Internships: The Museum maintained its collaboration with the Bergen Academy for Technology and Computer Science, working with six high school interns under the supervision of Co-Investigator Carter Emmart. These interns contributed to enhancing visualizations in OpenSpace by implementing code for the Cassini spacecraft and Mars rover.

Additionally, a master's student from NYU's Science, Health & Environmental Reporting program completed a semester-long internship, during which they created social media and blog content showcasing OpenSpace.



Five Digital Flight School students present on the Kuiper belt in OpenSpace.

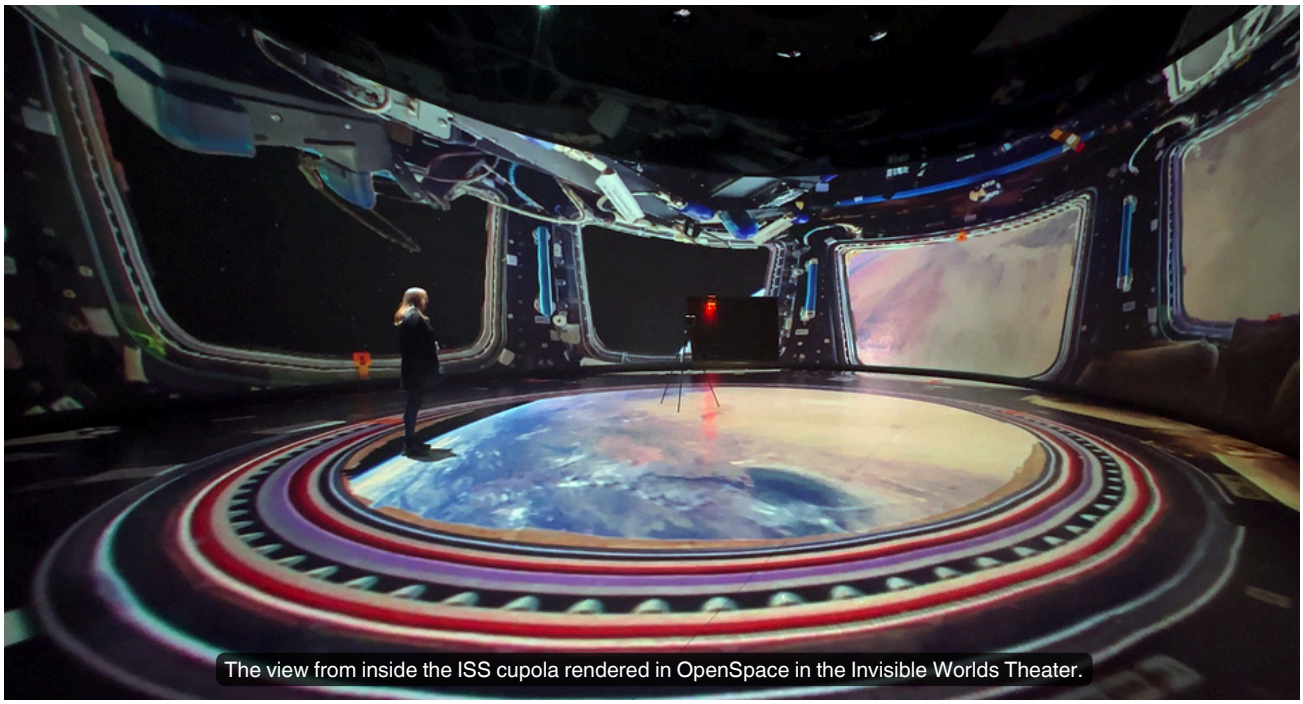
Education Programming: OpenSpace was also used in four one-week sessions of the Museum's Digital Universe Flight School where 105 middle school students learned to pilot the software. The software was regularly used in classes such as Ocean Worlds, Stellar Systems and Investigations Camp reaching an additional 202 students.

As part of the NASA TEAMS II-funded Urban Skies Project led by Michigan Science Center, AMNH is engaging 12 7th and 8th grade students in Junior Navigators, a course utilizing the newly developed youth-facing interface for OpenSpace being developed by the Urban Skies project this fall.

Since 2020, AMNH's Museum at Home program has engaged diverse audiences across the Americas and Europe, bringing virtual space exploration experiences to global communities through partnerships with various organizations such as 3M Latin American, Fundación Coppel México, and Google. In Year Nine, Museum Senior Scientist Jackie Faherty presented pre-rendered OpenSpace content, dubbed into Spanish, across four sessions at CosmoCaixa, a science museum in Barcelona, engaging 526 attendees. To date, the program has reached over 17,000 Spanish-speaking participants worldwide.

Pre-service Teacher Preparation: The Museum's Masters of Arts in Teaching Earth Science Residency Program (MAT-ESRP) consistently integrates OpenSpace into the training of its ≈20 graduate students. Upon graduation, these teachers commit to serving high-needs 7th–12th grade public school classrooms in the U.S., with most choosing to teach in New York City. Throughout their studies, the students use OpenSpace in various capacities, including for required coursework and as part of an astrophysical research capstone project. Additionally, 26 MAT ESRP alumni participated in two different workshop offerings held at the Museum, where they received in-depth training on using OpenSpace, including how to record videos for classroom use.

Exhibition Content: Visualizations rendered in OpenSpace are featured in new exhibit content in the Museum's Hall of the Universe. Four interactive kiosks enable visitors to explore the engineering and science goals and discoveries of the New Horizons, Parker Solar Probe, Gaia, and Planck missions, while an adjacent large-screen display, central to the hall's design, features the James Webb Space Telescope.



The view from inside the ISS cupola rendered in OpenSpace in the Invisible Worlds Theater.

Outreach: Finally, project staff and the growing group of OpenSpace pilots at AMNH organized several training sessions, demonstrations, and conference presentations, which are further detailed below.

California Academy of Sciences (Cal Academy)

In Year Nine, the California Academy of Sciences expanded its reach by continuing to adapt its live presentations of OpenSpace to a variety of different venues, reaching **305,286** people onsite and **47,472** online**.**

The Morrison Planetarium continued its Tour of the Universe daily programming, taking attendees on a journey from Earth to the Cosmic Microwave Background in OpenSpace, stopping at varying destinations in between. Over 36,000 people experienced these tours in Year Nine, with an additional 641 people joining via simulcasts to the Planetarium's Facebook page and the OpenSpace YouTube channel.

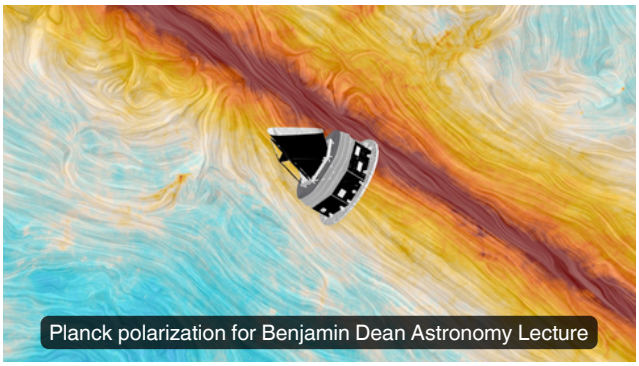
In November, Cal Academy premiered its fulldome show, Spark — The Universe In Us, featured live-flight sections of OpenSpace, adding an interactive dimension to the experience. This show was also featured as part of the NightLife program, which invites adults 21 and over to explore the museum after hours. Across 70 NightLife events, over 11,000 adults attended.

Programming continued outside the dome with family-friendly, 15-minute interactive presentations in Hohfeld Hall. These sessions, hosted by planetarium staff, covered a range of topics throughout the year, including Asteroid Adventures, Sun & Space Weather, and Rocket Road Trip.


Mary Holt presents to a young audience in Hohfeld Hall.

In addition to regular programming, the Academy's Benjamin Dean lecture series continued, offering recent scientific insights to adult audiences each month. Year Nine topics included *The Future of Human Exploration of Mars* with Dr. Pascal Lee (Mars Institute, SETI Institute, NASA Ames Research Center) a*nd NASA Spacecraft Swarms for Low Earth Orbit and Beyond* with Scott Miller (NASA Ames Research Center). These lectures were attended by 1,252 people in person, with an additional 110 joining online.


NASA's Starling mission for Benjamin Dean Astronomy Lecture

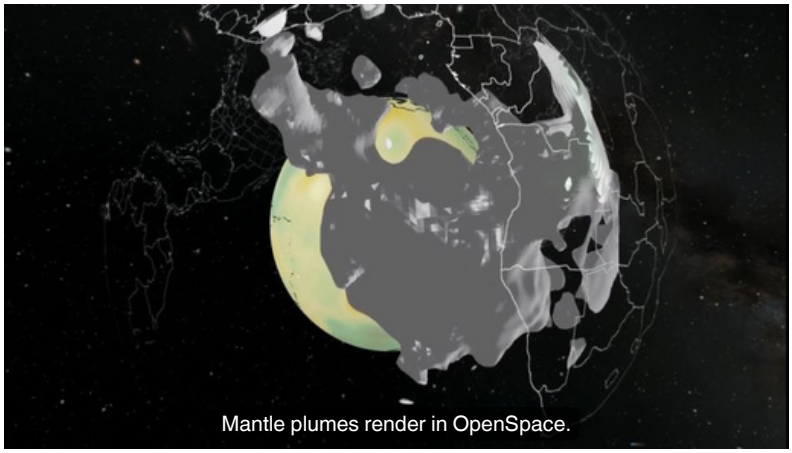

Planck polarization for Benjamin Dean Astronomy Lecture

OpenSpace videos were featured in the Academy's distance learning programs. The Ring of Fire eclipse class was presented to 21,675 students in 591 classrooms, while the Total Solar Eclipse class on April 3, 2024, reached 24,836 students in 634 classrooms, further expanding the Academy's educational impact.

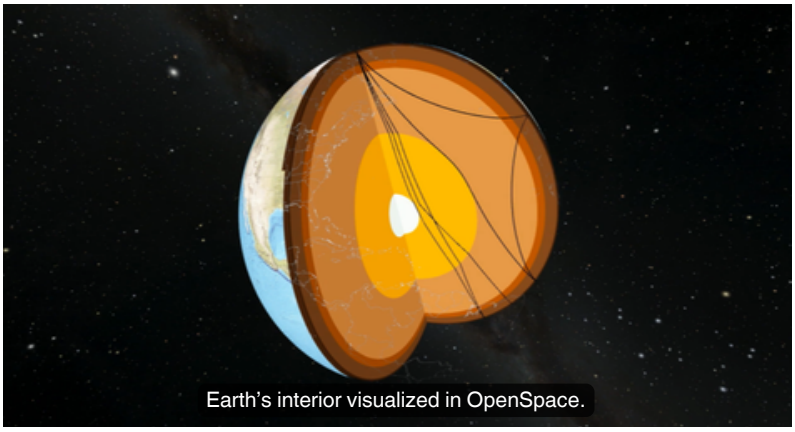
Denver Museum of Nature & Science (DMNS)

In Year Nine, Denver Museum of Nature & Science continued to push the boundaries of using OpenSpace for geoscience programming through its Digital Earth series in the Gates Planetarium, reaching over **500** people onsite. In November 2023, DMNS presented Digital Earth: Colorado River, which looked at how communities in multiple states are adapting to diminishing water supplies. The program used 360° panoramic photography to transport audiences to locations in Colorado, Nevada, and Arizona. In May 2024, Digital Earth: Groundwater incorporated maps showing dropping groundwater levels on the High Plains Aquifer, geospatial datasets of river drainages, and 360° panoramic photography to tell a story of how agricultural producers are adapting to drought and reduced water availability using more sustainable practices.

DMNS is also producing a two-part Digital Earth series on how energy is produced in the U.S., with a November 2024 program on energy of the past, and a follow-up in early 2025 on the ongoing revolution in renewables that will power the future. These programs deal with issues involving the intersection of science and society, helping attendees understand the complex systems that provide our freshwater, food, and electricity, and how they are being stressed by factors like climate change. The DMNS programs also highlight how communities can flourish while using less water; how innovations in farming practices allow farmers to do more with less; and how novel technologies and new ways of thinking are enabling the energy transition. DMNS also pioneered the use of OpenSpace for visualizations of Earth's interior, including mantle plumes derived from seismic data in Journey to the Center of Digital Earth, with current plans for a follow-up program in 2025 that will incorporate new volumetric models.



Mantle plumes render in OpenSpace.



Earth's interior visualized in OpenSpace.

On-floor staff educators are planning to switch to OpenSpace (away from another planetarium visualization software) for their live Travelin' presentations to student and general public audiences in DMNS' Space Odyssey permanent exhibit. In January 2024, OpenSpace training sessions were held for 15 educators. After a period during which the educators familiarized and practiced with the software during their free time, a follow-up series of training sessions were held in October. Starting in November 2024, these education staff will begin to change over to OpenSpace for their interactive tours of the universe with DMNS guests.

Houston Museum of Natural Science (HMNS)

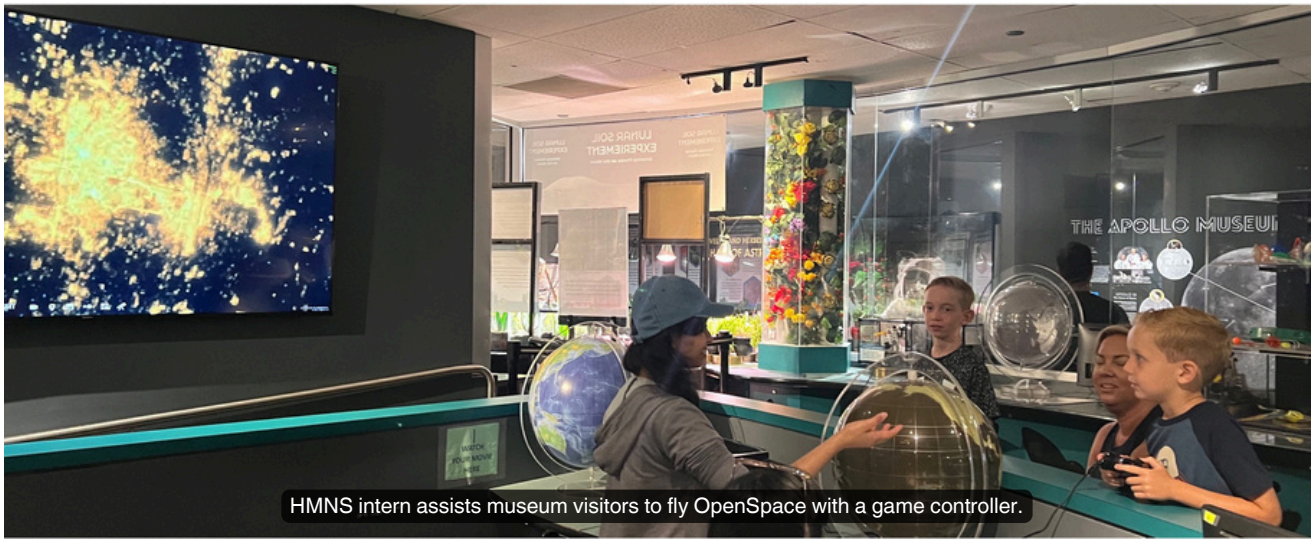
The Houston Museum of Natural Science continued to integrate OpenSpace into a wide range of educational and public-facing programs, reaching over **195,755** in Year Nine.

As Houston found itself in the path of totality, HMNS had an active year of eclipse outreach. The museum's "Totality Over Texas" fulldome film, which includes several scenes created with OpenSpace, was viewed in person by over 147,600 people at the HMNS Burke Baker Planetarium and in more than 140 other licensed planetariums, and an additional 3,800 online.

Eclipse content in OpenSpace was also boosted by HMNS's 21 high school summer astronomy interns this year. These interns supported solar viewing demonstrations to prepare for eclipses by teaching visitors how to use eclipse glasses and pinhole projectors, as well as provided informational handouts for upcoming eclipses. In addition to eclipse programming, interns worked on producing sections in OpenSpace for a future planetarium show called "The Cosmic Connection." These interns also played an integral role in the OpenSpace Lab to complete a variety of projects, offering OpenSpace demonstrations to museum visitors and working on the interactive games.

HMNS interns at work developing scenes for an upcoming planetarium show.

The OpenSpace Lab, a hands-on learning space in the museum, welcomed visitors to explore OpenSpace through a range of games and visualizations. In Year Nine, student interns presented in the Lab, flying through space and letting visitors find their way home or blast off to another planet. The OpenSpace Lab attracted 35,500 visitors who interacted with simulations, while around 18,000 explored additional exhibits in the Space Hall, including a meteorite display and a regolith-based plant exhibit created by interns.



HMNS intern assists museum visitors to fly OpenSpace with a game controller.

Additional OpenSpace-supported programs enriched visitor engagement through various programs and events, such as the Expedition Center's Mars landing simulation, an intern-led Summer Solstice program, and an interactive theater experiment with OpenSpace. These programs were attended by 7,641 visitors. HMNS also welcomed 1,200 students attending summer camp to experience new OpenSpace content.

North Carolina Museum of Natural Sciences (NCMNS)

In Year Nine, NCMNS leveraged OpenSpace to enhance visual storytelling across public programs, in community and school presentations, and in exhibition content. These efforts engaged a total of **264,183** on-site visitors and **100** online participants.

This year's Astronomy Days centered on asteroids and meteorites and featured several talks using OpenSpace including "Rocky Worlds: Impacts and Origins" with Dr. Rachel Smith, "Spectacular Sites We Drove to on the Moon" with Carter Emmart, and "First Look at Bennu Samples Returned by the OSIRIS-REx Mission" with Invited speaker Dr. Pierre Haenecour (University of Arizona). The weekend event welcomed 13,703 visitors to the museum.

Rachel Smith presents asteroids in OpenSpace during NCMNS Astronomy Days.

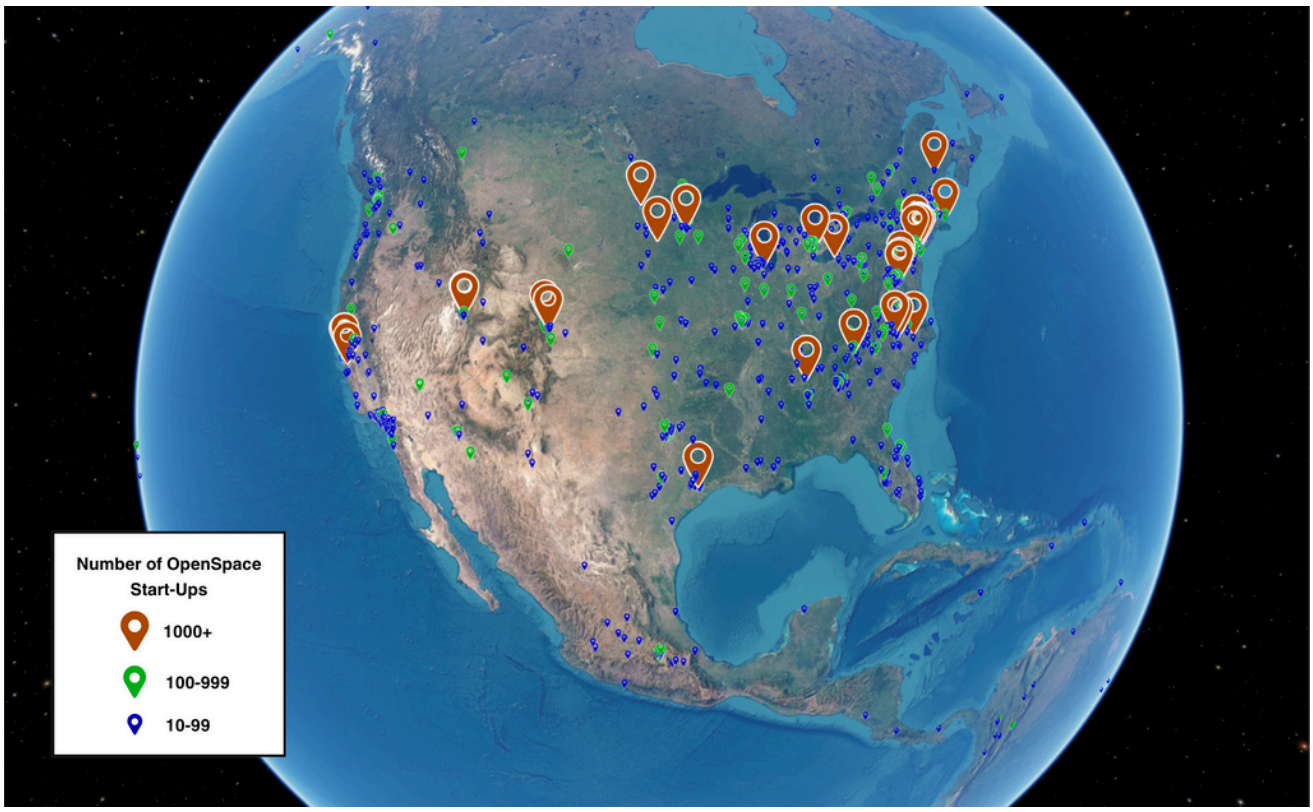
Co-I Smith continued to offer numerous in-person programs utilizing OpenSpace throughout Year Nine. Several programs engaged adults such as a Taylor Swift themed Museum after-hours event, and a presentation featuring OpenSpace in the museum's Daily Planet theater for World UFO Day. Additional presentations included "Exoplanets, Interstellar Travel, and Galactic Civilizations: Science in the Star Wars Universe" for NCMNS's Star Wars "May the Fourth be with You" event in the Daily Planet theater and "Asteroids, Meteorites, and Life Beyond Earth" for the Osher Lifelong Learning Institute hosted by NC State. These programs reached over 1,230 people.

Throughout Year Nine, the museum's interactive kiosks featuring curated videos continued to be a major attraction for visitors of all ages. The thematic, user-driven video kiosks offer on-demand OpenSpace videos that highlight a range of data such as asteroids, Voyager, and JWST. Additionally in Year Nine, two undergraduate interns updated the content offerings of the Astronomy & Astrophysics Research Lab, including a new video discussing the journey of meteorites from the solar system to museum collections. The Lab was also opened during special event galas for exhibition openings at the museum, attracting more than 5,600 visitors to the Lab.

Dr. Smith is an avid promoter of OpenSpace, and has expanded its reach to multiple institutions. Additional uses of OpenSpace in conference presentations and by partner institutions, the Appalachian State University and Museum of Life and Science, are described in the next section.

Instances of OpenSpace Start-ups

The above ISI uses are known to the project team through regular reporting, however there are many more instances of OpenSpace being run around the world. Some of these we become familiar with through colleagues, conferences, or our public Slack channel. Others remain unknown to us. The map below is a comprehensive snapshot of OpenSpace software startups for North America since 2021.



Additional Year Nine Community, Academic, and ISI Activities

The following is a sampling of known activities using OpenSpace **beyond the funded partners** listed by geographical area. The project team is continuously learning about the growth of the project beyond known users and it is therefore impossible to paint a complete picture of OpenSpace's reach and impact. This is further explained in the Network Evaluation Report attached in *Appendix B*. New users are denoted with an asterisk.

UNITED STATES

Appalachian State University (Boone, NC)

NCMNS Co-Investigator Dr. Rachel Smith incorporated OpenSpace into her "Astrobiology: Exploring Life in the Universe" course at Appalachian State University for both the fall 2023 and spring 2024 semesters, as well as her upper-level “Star Formation” course, providing immersive experiences for 79 students. Throughout the semester, students explored the universe through OpenSpace, using it to understand astrobiology concepts, including cosmic structure, planetary features of Earth and Mars, and topics related to habitability and the Search for Extraterrestrial Intelligence (SETI). Additionally, Dr. Dan Caton, fellow professor and director of Appalachian State's Dark Sky Observatory, used OpenSpace in his public observing nights, engaging 245 participants with tours of the night sky.

***Applied Research Laboratory at the University of Texas at Austin (ARL:UT) (Austin, TX)**

At the Applied Research Laboratory, presentations using OpenSpace have been regularly conducted for staff, interns, and students. The tool has proven to be an invaluable resource for teaching non-astronomers about satellite data and GPS, significantly enhancing their understanding of the subjects they are working on. ARL:UT aims to integrate satellite data into OpenSpace and has already integrated data from Hobby-Eberly Telescope Dark Energy Experiment (HET-DEX).

City College of New York (CCNY) Planetarium (New York, NY)

In Year Nine, CCNY Planetarium continued its OpenSpace programming through weekly free public shows. Across 25 live-flight shows, CCNY reached more than 300 visitors, including CCNY students as well as the NYC community. Orchestrated by Planetarium Director Dr. James Hedberg, the CCNY Planetarium offered special shows for various groups on campus, such as an alumni event and a show with the Art Students League of NYC exploring lunar-related public sculpture with OpenSpace. Recently added profiles also played a key role in CCNY Planetarium’s live shows highlighting upcoming missions, like Artemis and Europa Clipper.

Additionally Dr. Hedberg continued to make popular, short educational videos to share on Instagram and other social media channels using OpenSpace to illustrate important concepts. The 26 videos explored a range of OpenSpace content such as the annular eclipse, Europa and Comet C/2023 A3, and lunar geography, with the most popular videos featuring music by Led Zeppelin, Peter Frampton, Talking Heads, and The Rolling Stones. In total, these videos have amassed 9.7 million views and 63,856 likes to date.

***Institute of American Indian Arts (Santa Fe, NM)**

A new user in Year Nine, the Institute of American Indian Arts (IAIA), representing students and faculty from over 90 recognized tribal groups, has used OpenSpace to take students on virtual flights over Earth, exploring landscapes from Santa Fe to the Rocky Mountains. They aim to add Indigenous constellations to OpenSpace potentially through student or faculty research, enriching the platform with diverse cultural perspectives in astronomy.

Lawrence Hall of Science (Berkeley, CA)

As a new user in Year Eight, Lawrence Hall of Science has expanded its OpenSpace use to engage more attendees. A daily public show, Diving into the Blue Planet, using OpenSpace to guide audiences around Earth, engaged 1,515 attendees of all ages. Additionally, Planetarium Pilots, a free walk-up activity for visitors, allows guests to fly the planetarium using an iPad to control OpenSpace. Over 7,000 visitors participated in Year Nine. This show was also presented several times over the summer to elementary school camps, reaching over 100 students.

Lower Eastside Girls Club (New York, NY)

In Year Nine, OpenSpace has become a core tool for engaging youth and community members in astronomy and space science at the Girls Club, which is dedicated to connecting young women and gender-expansive youth of color throughout New York City to healthy and successful futures through free, innovative year-round programming and mentoring. OpenSpace programming reached 913 participants at 22 programs, including student orientation, where OpenSpace was used to introduce over 80 students (grades 4–12) to the Girls Club STEM offerings. The Girls Club also had two dedicated OpenSpace classes with 24 students, a Summer Camp event for 40 youth (grades 4–8), and community programs like a jazz show and a public planetarium event, collectively reaching 189 adults. In addition, 15 field trips brought diverse student groups from area public schools to the planetarium reaching 527 children ranging from kindergarten to 7th grade.

OpenSpace visuals at the Lower Eastside Girls Club during the Cassandra Jenkins album release listening party.

Mayo High School (Rochester, MN)

In Year Nine, Mayo High School's 30-foot diameter planetarium welcomed 19,185 visitors across 621 shows. The majority of these attendees were children in grades K-5, although 36 adult evening shows and various community clubs and organizations also enjoyed the experience. In Rochester, MN, 35.5% of students are eligible for the federal free and reduced-price meal program, and 8.8% are English language learners.

During each show, OpenSpace is utilized to explore Earth and its features—such as craters, and islands—as well as to journey to the Moon, examine planets, investigate exoplanet systems, and even reach the edge of the observable universe. Students consistently express awe when experiencing OpenSpace in full-dome format.

Michigan Science Center (Detroit, MI)

The Michigan Science Center utilizes OpenSpace in its fixed dome. For the 2023–2024 school year, the center engaged all third-grade students in the Detroit Public School Community District, reaching 8,500 students and members of the public through this program. In the summer of 2024, they developed a show titled “What’s Out There: The Universe’s Best Kept Secrets,” which highlighted lesser-known facts about the universe and attracted 2,353 student participants.

Additionally, the Michigan Science Center hired a web developer to create a Youth Learner interface specifically designed for middle school students. Through a TEAM II NASA grant, the center will teach these students how to use OpenSpace, allowing them to create their own mini shows. Once the final version of the web interface is completed, it will be made freely available to anyone interested in using it with OpenSpace. (The Youth Learner interface will be further developed and implemented in Year Ten to expand access to the software to users of all proficiency levels.)

Minnesota State University Moorhead (MSUM) Planetarium (Moorhead, MN)

In Year Nine, the MSUM Planetarium further integrated OpenSpace into its space science programming. Following a semester where undergraduate students operated the dome, two dedicated students had summer internships to develop a tool to map images onto the constellations. This allows the planetarium to create custom assets such as constellations based on Harry Potter characters, a crowd favorite. Throughout this project, the students honed their STEM skills by developing the constellation mapping tool in Python.

Museum of Life and Science (Durham, NC)

The Museum of Life and Science, a partner institution of NCMNS, has continued to collaborate with Co-I Dr. Rachel Smith to highlight OpenSpace. In Year Nine, the museum's lunar surface video rendered in OpenSpace permanently on display in the Aerospace exhibit reached over 159,700 people.

Museum of Science, Boston (Boston, MA)

Charles Hayden Planetarium at the Museum of Science, Boston was updated with OpenSpace software this year. In October, the museum hosted a program specifically for local researchers to explore 3D datasets of the Milky Way. The museum plans to coordinate public programs with AMNH in Year Ten.

Planetarium at P-Tech (Paterson, NJ)

The Planetarium at P-Tech primarily serves the Paterson Public School District, which includes 27,000 students from Pre-K–12, predominantly from marginalized groups, all of whom receive free breakfast and lunch. OpenSpace has been utilized in various evening events at the Paterson Museum, as well as in after-school programming. Additionally, videos created using OpenSpace are shared with students through Google Classroom and district-wide emails. Through programs both during school hours and outside of school hours OpenSpace engaged 1,315 students and 254 adults.

Southwest Minnesota State University (SMSU) (Marshall, MN)

OpenSpace continues to be the primary outreach tool at the Southwest Minnesota State University Planetarium. Over the past year over 5,000 people, ranging in age from Preschool to senior citizens, have been engaged with OpenSpace. The primary group engaged was K–12. Primary topics include: Nightsky (backyard astronomy), planet tours (globe browsing) of Earth, Moon, Mars, Europa, Io, and Pluto, Exoplanets, JWST (skybrowser), Galaxy data sets, and Cosmic Background Radiation.

University of Nebraska–Lincoln Ralph Mueller Planetarium (Lincoln, NE)

At the Ralph Mueller Planetarium, OpenSpace has reached 164 attendees through class trips and eclipse programming. Staff have developed three shows to present live for various audiences. For 5th and 6th graders, 64 students attended a session where OpenSpace was used to explore why the visible stars change throughout the year. For 7th and 8th graders, 20 students participated in a show that used OpenSpace to examine the scale of the universe. Additionally, one of the museum's science communication interns created an eclipse show using OpenSpace, conducting four shows for 80 attendees. OpenSpace will be utilized for a series of field trips in November 2024.

Additional Known ISI Users (New users are denoted with an asterisk.)

- A Time for Science (Greenville, NC)
- Anchorage Museum (Anchorage, AK)
- Asheville Museum of Science (Asheville, NC)
- Astronomy on Tap (New York, NY)
- ASU School of Earth & Space Exploration (Tempe, AZ)
- ASU Thunderbird School of Global Management (Phoenix, AZ)
- Austin Community College (Austin, TX)
- Brookhaven National Laboratory (Upton, NY)
- Brooklyn Technical High School (Brooklyn, NY)
- Charleston Planetarium Society (Charleston, SC)
- Como Park Elementary School (Saint Paul, MN)
- Connecticut Science Center (Hartford, CT)
- Fiske Planetarium, University of Colorado Boulder (Boulder, CO)
- Hampden Sydney College (Hampden Sydney, VA)
- Herndon High School (Herndon, VA)
- Hubble Planetarium (Brooklyn, NY)
- *Imiloa Astronomy Center (Hilo, HI)
- Intrepid Sea, Air & Space Museum (New York, NY)
- Jewish Museum of Milwaukee (Milwaukee, WI) (Temporary)
- *Jim and Linda Lee Planetarium (Prescott, AZ)
- Laurel Highland School District (Fayette County, PA)
- Mankato East High School (Mankato, MN)
- Muscle Shoals Middle School (Muscle Shoals, AL)
- New Brighton Area Schools (New Brighton, PA)
- New York University (New York, NY)
- Nyx Space (Golden, CO)
- Oakton High School (Oakton, VA)
- One World Immersive (Denver, CO)
- Paulucci Space Theater (Hibbing, MN)
- Phillip and Patricia Frost Museum of Science (Miami, FL)
- *Raritan Valley Community College (Branchburg, NJ)
- Robeson Planetarium (Lumberton, NC)
- Science Museum of Western Virginia (Roanoke, VA)
- *Sci-Port Discovery Center (Shreveport, LA)
- Spherical (Oakland, CA)
- Springfield Science Museum (Springfield, MA)

- StoryDome (Langley, WA)
- Towson University (Towson, MD)
- The B612 Foundation (Mill Valley, CA)
- The Human Space Program (Natick, MA)
- The Journey Museum (Rapid City, SD)
- University of North Dakota (Grand Forks, ND)
- University of Utah (Salt Lake City, UT)
- *University of Washington Planetarium (Seattle, WA)
- Versant Power Astronomy Center, University of Maine (Orono, ME)
- Wauwatosa West High School (Wauwatosa, WI)
- West Springfield High School (West Springfield, VA)
- West Virginia University (Morgantown, WV)

EUROPE

Norrköping Visualization Center C (Norrköping, Sweden)

OpenSpace has been widely used across various educational and public programs at The Center. School programs, targeting pupils aged 14–15, have engaged 313 students in interactive sessions, while preschool programs for children aged 3–5 reached 181 young learners. These programs offer hands-on experiences with OpenSpace in small groups, engaging students in many aspects of space science. Additionally, The Center hosted 4,648 attendees in 187 public shows using both live and recorded OpenSpace content, offering a mix of real-time visualizations and pre-recorded experiences to diverse audiences.

OpenSpace has also been integrated into the Science Center, where over 100,000 visitors had the opportunity to interact with OpenSpace installations via joysticks for simulated flights, holograms, and touch interfaces. The recorded version of the OpenSpace "Vast" show, presented at multiple Wisdome sites, has sold 43,353 tickets this year across five venues. Furthermore, the "Vast" experience has been licensed to 11 additional domes worldwide.

Norrköping Visualization Center C is visited by Axiom space astronauts including Marcus Wandt.

Beyond public engagements, around 500 visitors at science festivals have participated in OpenSpace demonstrations, and 20 Science Center educators received training on how to effectively use the software in educational settings. A new script focused on "Water in the Solar System" for students aged 10–15 has also been developed as part of the ESERO Sweden program.

Kindergarteners enter the SpaceDome.

SpaceDome Mobile Planetarium (Zürich, Switzerland)

SpaceDome, a portable planetarium in Switzerland, presented 108 shows using OpenSpace, reaching a total audience of 3,903 attendees in Year Nine. The majority of these programs took place at primary schools, with most participants aged between 6 and 12 years old. Additionally, four shows were held at a regional space festival, and nine shows were conducted during a four-day family event in the Swiss Alps. Three shows were specifically designed for children with physical and mental disabilities, ensuring inclusivity in their programming.

Additional Known ISI Users (New users are denoted with an asterisk.)

- Ars Electronica Center (Linz, Austria)
- Astro Group South Sardinia (Castiadas, Sardinia, Italy)
- Astrolab Iris (Ieper, Belgium)
- Bromsgrove School (Bromsgrove, United Kingdom)
- Exploratório - Centro Ciência Viva de Coimbra (Coimbra, Portugal)
- National Museum of Science and Technology (Stockholm, Sweden)
- Naturhistorisches Museum Wien (Vienna, Austria)
- Sonnenborgh (Utrecht, Netherlands)
- Technical University of Munich (Munich, Germany)
- The Admiral Vasile Urseanu Astronomical Observatory (Bucharest, Romania)
- Umevatoriet (Umeå, Sweden)
- Universeum (Gothenburg, Sweden)
- Universidad de Córdoba (Córdoba, Spain)
- University of Groningen (Groningen, Netherlands)
- VEGA Haus der Natur observatory (Salzburg, Austria)
- *Malmö Museum (Malmö, Sweden)
- WonderDome (Sheffield, United Kingdom)
- ZOOM Children‘s Museum (Vienna, Austria)

CANADA

***Ontario Science Centre (Toronto, Ontario)**

At the Ontario Science Centre, a continuous flight video was created using OpenSpace, taking viewers from Earth to the Cosmic Microwave Background Sphere and back, with the Radiosphere activated to provide a sense of scale within the Milky Way. This awe-inspiring experience served as an emotional hook for exploring scientific concepts. This video was incorporated into the "You and the Universe" Grade 9 School Program for the 2023/2024 school year, reaching over 750 students.

Additional Known ISI Users

- Aquatarium (Brockville, Ontario, Canada)
- IMERSS (Galiano Island, BC, Canada)

SOUTH AMERICA

Mochileros Astronómicos / Planetario Canopus (Asunción, Paraguay)

Planetario Canopus continued using OpenSpace in schools and communities across Paraguay, engaging with over 10,000 individuals through 45 programs at schools, shopping malls, cultural events, and tourist fairs.

Planetario Canopus programs include interactive content that blends astronomy, science, and fiction, enhancing the popularization of these STEM subjects. Notable adaptations include presentations of The Little Prince, Dinosaur World, and various models of space missions and astronomical phenomena. Additionally, OpenSpace has been adapted to run effectively on basic performance laptops as well as high-performance systems, showcasing its versatility for various technical setups and venues.

Students look up at the Earth's magnetosphere in Planetario Canopus' portable planetarium.

OCEANIA

***Spaceward Bound NZ (New Zealand)**

Over the past three years, Spaceward Bound NZ, a space science outreach organization in New Zealand, has used OpenSpace as the primary display in a portable planetarium, bringing interactive space science experiences to schools and communities nationwide. With a capacity of 20–25 visitors, the planetarium has reached 27,577 students across 161 schools and engaged 7,233 people at 24 public events. Through OpenSpace, audiences of all ages explore craters on the Moon and Mars, inspiring lifelong curiosity in space science. The organization credits OpenSpace with revolutionizing its outreach and expresses deep gratitude to the project team and funders for making it possible.

A class visits Mars during a presentation by Spaceward Bound NZ.

Additional Known ISI Users

- New Zealand Astrobiology Network (Carterton, New Zealand)
- University of New South Wales Wollongong (Wollongong, Australia)

AFRICA

***The Naval Hill Planetarium at the Centre for Earth and Space (Bloemfontein, South Africa)**

The University of the Free State was awarded a grant from the United States Embassy in South Africa for the project “Space and Satellites: Awareness and Observations”. The OpenSpace team will facilitate a training for Naval Hill Planetarium staff and other planetarium professionals from South Africa in January 2025. The software is also being installed in the planetarium to seamlessly move from the classroom to the dome.

Additional Known ISI Users

- African Circular Business Alliance (Cape Town, Western Cape, South Africa)
- *ATTARIK Foundation (Casablanca, Morocco)
- Ghana Planetarium (Accra, Ghana)
- University of Cape Town (Cape Town, South Africa)

ASIA

Additional Known ISI Users (New users are denoted with an asterisk.)

- *Sri Sathya Sai Space Theatre (Puttaparthi, India)
- Traveling Universe (Chiang Mai, Thailand)

Finally, OpenSpace has received interest or started installation conversations with six institutions in Year Nine, that we will pursue into Year Ten:

- Air Zoo (Kalamazoo, MI)
- Francis Malcolm Science Center (Easton, ME)
- Joseph Moore Museum at Earlham College (Richmond, IN)
- New Jersey State Museum (Trenton, NJ)
- Parque Explora (Medellín, Colombia)
- Planetarium Stellarium Erkrath (Erkrath, Germany)
- Vaughan Planetarium (Laramie, WY)
- Williamsville Space Lab Planetarium (Williamsville, NY)

Emerging OpenSpace Ambassadors

In addition to use by the above organizations, a growing group of individual astronomy hobbyists is emerging as OpenSpace "ambassadors," actively reaching out to communities outside of traditional ISIs. Standout examples include:

Space Case Sarah

Under the moniker "Space Case Sarah," Sarah Treadwell utilized OpenSpace in a portable planetarium with her local community. Over the course of 6 weeks in the spring of 2024, she visited 12 elementary schools in Rockford, IL, reaching 1,782 children and educators. The experience left a strong impact, with one 1st grader from Brookview Elementary exclaiming, "It feels like we're really in space!" When asked if they wanted to be an astronaut, a 4th grader from Lanthrop Elementary responded, "No. When I grow up, I want to be like you!" In the summer and fall of 2024, Sarah has also utilized OpenSpace in partnership with the Rockford Public Library, Rockford Miracle Mile, and the city of Rockford to reach approximately 500 individuals through outreach at various locations.

Sarah Treadwell presents to a class in Rockford, IL.

Luana Melnek dos Anjos

As an astrophysics student at San Francisco State University, Luana Melnek dos Anjos has sought out opportunities to share space science outside of traditional learning environments. Luana has shared OpenSpace in a number of nonconventional locations including sidewalks, farms, rooftops, and even a train café car. Luana shared her work in this blog post and continued to use OpenSpace for eclipse outreach in Year Nine.[4]

Children fly OpenSpace in a cafe train car with support from Luana Melnek dos Anjos.

Brian Levine and **Irene Pease**

NYC-based educators Brian Levine and Irene Pease regularly provide programming with OpenSpace during Astronomy on Tap events and in addition led a training session on the eclipse for 25 Brooklyn Public Library librarians using OpenSpace content.

Planetarium Vendors

The OpenSpace project team has continued to foster relationships with vendors to broaden distribution of the software and enable support for users regardless of their technical infrastructure. The Elumenati has invested in OpenSpace as its premiere source for astronomy content and invited the OpenSpace project team to participate in its first GeoDome User Meeting in May 2024. Additionally, we've teamed up with SSIA Technologies for several dome installations, with our Software Integration Engineer spearheading the OpenSpace updates. The OpenSpace project has also received interest from Ash Enterprises and Digitalis about integrating the software into their systems. Meanwhile, Turkey-based SureyyaSoft has merged OpenSpace with their Shira Presenter tech in the Shira Dome Console.

4 https://www.openspaceproject.com/blog/2024/4/1/breaking-barriers-luanas-journey-from-community-to-the-cosmos

Through collaboration with Cosm, the latest version of OpenSpace includes improved support for the Multiple Projector Common Data Interchange (MPCDI) format facilitating integration with its Digistar systems. This update opens doors for broader distribution across institutions serviced by Cosm / Evans & Sutherland, the leading global planetarium provider. Finally, preliminary conversations with RSA Cosmos and BWC Visual Technology are underway, with plans to continue these discussions into Year Ten.

III. Status/Changes/Issues

Issues

Apple's M-class chips continue to pose a problem for OpenSpace users as the chips do not support double precision floating point operations, which are crucial to handling the resolution and size of some data sets and the vast spatial scales covered in the software.

We continue to release the software for older Intel Macs as research on this problem is ongoing. An NYU developer is working on overcoming the issue, with promising results, including a solution to visualizing high-resolution terrain maps on Apple's M-class chips. More testing is necessary, however, to be fully operable on Macs.

In addition to solving this problem natively on Macs, the development of OpenSpace Cloud, which is being funded through our augmentation, will enable Mac users to run OpenSpace through a Web GUI.

Personnel Changes

Two part-time developers have been hired at NYU Tandon School of Engineering. These engineers are working with computer science professor Co-I Dr. Claudio Silva to design and test the interface of OpenSpace Cloud.

IV. Dissemination Activities, Collaborators, Cross-Collaboration Agreement Activities

Website (www.openspaceproject.com)

The OpenSpace website serves as the primary destination for new and returning users, as well as non-users interested in accessing OpenSpace content and events. The website provides an overview of the project, introduces our team, highlights opportunities for involvement, and offers a direct download of the software. Visitors can also connect to our community Slack workspace, follow us on social media, and explore upcoming events.

Since November 2023, the website has attracted over 74,000 visits, a 14% increase from Year Eight, from more than 60,000 unique users. Leading the way, over 40% of visitors were from the United States, with significant engagement from Germany, Sweden, India, the United Kingdom, Canada, the Netherlands, China, Russia, France, Australia, and Spain—each logging over 1,000 visits. In addition, visitors from 44 more countries surpassed the 100-visit mark, illustrating OpenSpace's global reach.

Traffic insights reveal that 55.7% of visits were direct, while 32.8% came through search engines like Google, Bing, and DuckDuckGo. The AMNH website served as the top referral source, driving over 2,000 visits. On Google alone, OpenSpaceProject.com earned over 18,000 clicks and 589,000 impressions.

Support and Community Channels

Docs (docs.openspaceproject.com**)**

The OpenSpace Docs site houses the software documentation and allows for multiple versions to be maintained on one site, supporting older versions of the software as well as the latest release. This platform also features code highlighting and callouts that helps users find the most relevant information.

GitHub (https://github.com/OpenSpace/)

GitHub hosts the public source code for OpenSpace. Both users and developers can report software issues, suggest fixes for bugs, and contribute to the codebase there. A total of 359 issues have been created in the main GitHub repository, with 201 remaining open and 158 resolved. In total, 280 issues have been closed and 979 changes committed, reflecting frequent updates to the codebase. Notably, 97 people have contributed to the code over the last nine years.

Reddit (https://www.reddit.com/r/OpenSpaceProject/)

The OpenSpace Reddit acts as an auxiliary support platform and a space to discuss software applications. The number of members increased in Year Nine to 131 members (up from 104 in Year Eight), with discussion predominantly related to support questions.

Slack (openspacesupport.slack.com; team-openspace.slack.com)

The project has 2 workspaces on Slack, one used by the project team, and one that serves as a hub for community-led collaboration. In response to naturally developing threads, we added announcement and conference channels. Simultaneously, we promoted user engagement in these channels. The public OpenSpace Support Slack now supports 1,065 members (up from 884 in Year Eight), with an average of 75 members actively participating each week.

OpenSpace Social Media Platforms

Facebook (@OpenSpaceVisualization)

In Year Nine, the OpenSpace Facebook page grew its follower count to 996. The account reached 1,400 unique users and recorded 694 profile visits, marking a 40.2% increase in profile visits compared to Year Eight.

Instagram (@openspaceproj)

The OpenSpace Instagram account saw significant growth over the past year. By the end of Year Nine, our follower count rose to 2,545, with over 2,100 profile visits, 61.5% more profile visits than last year. The nine content-focused videos posted during this period garnered a total of 11,581 views, while all content from Year Nine achieved a cumulative reach of 9,200, a 23.3% increase in reach from Year Eight.

LinkedIn (@OpenSpace)

The OpenSpace LinkedIn page has served as a platform for sharing industry updates, including participation in conferences. Over the past year, our content reached 363 members, while the page recorded 243 views and increased its follower count to 211.

TikTok (@openspaceproj)

In Year Nine, the OpenSpace Science Communication intern piloted the use of TikTok by repurposing short-form videos initially created for Instagram. Across nine videos, the OpenSpace account generated 155,207 views, reached 143,658 unique accounts, and attracted 1,167 profile views.

X (@openspaceproj)

Our followers on the platform increased to 1,171, with the account generating over 20,900 impressions. We are assessing whether we will continue on this platform.

YouTube (www.youtube.com/c/OpenSpaceSoftware)

This year, the OpenSpace YouTube channel garnered over 406,925 impressions, 32,741 views, and more than 1,100 hours of watch time (excluding AMNH and other partner channels). Total subscribers rose to 3,420. Approximately 25% of viewers were from the United States, with India as the next largest audience at 3%. Two How-To tutorials were produced in Year Nine, demonstrating how to visualize eclipses and moon phases in OpenSpace, and these videos have received 933 views. The OpenSpace team plans to continue developing this video format in Year Ten.

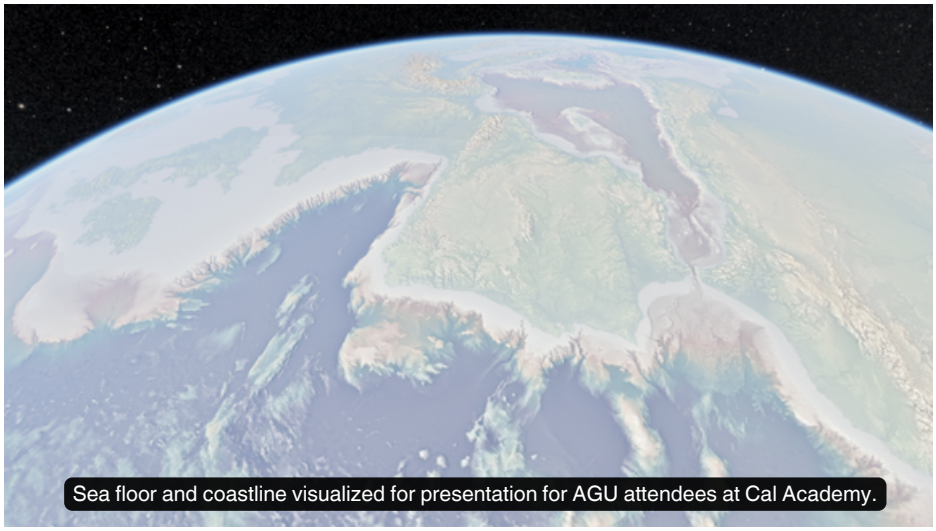
Press Coverage

Visualizations from OpenSpace were featured in several news articles highlighting the discovery of over 27,000 previously overlooked asteroids, including the New York Times[5], Smithsonian Magazine,[6] and Space.com.[7] Eclipse visualizations using OpenSpace were also published.

Conferences, Colloquia, and Symposium

American Geophysical Union (AGU) (December 11–15, 2023)

Multiple sessions at the 2023 AGU Fall Meeting included OpenSpace content. Co-I Carter Emmart delivered presentations on "Producing with Data Visualization to Show the Complexity of Earth Systems" and "Engaging the Public with NASA Data." He also conducted two software demonstrations at the NASA exhibit booth. Additionally, a program at the California Academy of Sciences highlighted a range of OpenSpace visualizations. Ebru Bozdag from the Colorado School of Mines and Ka Chun Yu from the Denver Museum of Nature and Science presented visualizations of mantle plume and seismic wave models. Emmart shared ongoing work on Apollo reconstructions, while Elana Resnick and Elon Olsson from NASA Goddard showcased the Community Coordinated Modeling Center (CCMC) heliophysics models.



Sea floor and coastline visualized for presentation for AGU attendees at Cal Academy.

[5] Kenneth Chang, *Killer Asteroid Hunters Spot 27,500 Overlooked Space Rocks*, New York Times (April 30, 2024). https://www.nytimes.com/2024/04/30/science/killer-asteroids-algorithm.html

[6] Aaron Boorstein, *Scientists Discover 27,500 Asteroids in Old Telescope Images Using A.I., Smithsonian Magazine* (May 6, 2024).

[7] Sharmila Kuthunur, *AI discovers over 27,000 overlooked asteroids in old telescope images*, Space.com (May 2, 2024). https://www.space.com/google-cloud-ai-tool-asteroid-telescope-archive

[8] Greg Heilman, *How do flat-earthers explain a total solar eclipse*, Diario AS USA (April 3, 2024). https://en.as.com/latest_news/how-do-flat-earthers-explain-a-total-solar-eclipse-n/

American Association of Physics Teachers (AAPT) (January 6–9, 2024)

Robert Steiner, Director of Online Teacher Education Programs at AMNH presented "OpenSpace: An Open-Source Tool for Astrophysical Visualization" for 25 high school and higher education physics teachers.

American Astronomical Society (AAS) (January 7–11, 2024)

Jackie Faherty, Senior Scientist at AMNH, presented OpenSpace with educator Deion Desir during the SciAct pre-conference workshop hosted by the Universe of Learning.

American Association for the Advancement of Science (AAAS) (February 15–17, 2024)

Ka Chun Yu, Denver Museum of Nature & Science, shared OpenSpace during two NASA Hyperwall presentations reaching 35 professionals.

55th Lunar and Planetary Science Conference (LPSC) (March 11–15, 2024)

Emmart presented a poster "A Stereographic Dome Production of the Apollo J-Mission Lunar Field Exploration Using LROC Terrain and Spatiotemporal Mapping of EVA Traverses."

National Science Teaching Association (NSTA) Conference (March 20–23, 2024)

Ka Chun Yu shared OpenSpace on the NASA Hyperwall for 25 educators.

NASA SMD Software Workshop (May 6–10, 2024)

Micah Acinapura presented "OpenSpace: A Versatile Visualization Tool for Exploring NASA Datasets" to 25 NASA engineers and staff.

Elumenati GeoDome Network Meeting (May 16–17, 2024)

Micah Acinapura and Megan Villa participated in the inaugural Elumenati user meeting, where they presented on a range of topics related to OpenSpace. Sessions included training on software functionality and core content, night sky astronomy, and customizing user content. This meeting was a great opportunity to connect with both new and established OpenSpace users. The 30 attendees ranged from planetarium directors to high school student planetarium club members.

Micah Acinapura shares how to present Night Sky astronomy in OpenSpace at the Elumenati GeoDome Network meeting.

Swedish e-Science Research Centre (SerC) Annual Meeting (May 16–17, 2024)

OpenSpace developer Emma Broman presented a poster “OpenSpace: An Exploranation Software for Research and Science Communication.”

National Rural STEM Learning Summit (June 4–7, 2024)

Rachel Smith presented “Sparking Connections in Rural Communities through Shared Interactions with Data” highlighting her experience using OpenSpace in rural settings. The session was attended by 50 participants.

Ecsite Conference (June 5–8, 2024)

OpenSpace developers hosted an OpenSpace booth sharing the software with other science center professionals.

International Planetarium Society (IPS) Conference (July 18–25)

OpenSpace users from AMNH, California Academy of Sciences, DMNS, Michigan Science Center and Linköping University presented 7 sessions on OpenSpace. Topics included geoscience visualizations, audience-centered interactive presentations, presenting in diverse venues, and more.

Paulette Epstein and Dan Tell present “Implementing OpenSpace as a low-cost planetarium solution” at IPS.

© SPB Foto Stageview

In addition, an OpenSpace booth featuring two touchscreen tables engaged over 500 attendees, and the OpenSpace Project team conducted sponsorship demonstrations in the dome.

Micah Acinapura and Alex Bock fly around OpenSpace for booth visitors. © SPB Foto Stageview

Several interested attendees explore OpenSpace at the booth during IPS.

Meteoritical Society Annual Meeting (July 28–August 2, 2024)

Rachel Smith presented OpenSpace content, including a flyover of Maunakea to 80 conference attendees.

Geological Society of America (GSA) Annual Meeting (September 22–25)

Rachel Smith presented two talks on the NASA Hyperwall for 25 attendees.

UN Summit of the Future (September 21, 2024)

During a special climate week session, Carter Emmart presented OpenSpace with Lorant Czaran, Scientific Affairs Officer, UN-SPIDER United Nations Office for Outer Space Affairs. The dome presentation used OpenSpace to highlight space's role in advancing sustainability, reaching 140 members of the UN. This presentation was reprised for another meeting of the UN, reaching an additional 220 members.

Heising-Simons Foundation's Annual 51 Pegasi b Summit (September 2024)

Jackie Faherty delivered the keynote speech including OpenSpace visuals for current and past 51 Peg b Fellows and university faculty members.

Association of Science and Technology Centers (ASTC) Conference (September 28–October 1)

OpenSpace hosted a booth to highlight the software to ISI professionals, reaching over 100 attendees. The Adler Planetarium presented an OpenSpace demonstration in the Grainger Sky Theater with Rachel Smith and Micah Acinapura presented the variety of data available in the software, reaching an additional 35 attendees.

Micah Acinapura presents Sloan Digital Sky Survey for ASTC attendees at the Adler's Museum Day event.

Great Lakes Planetarium Association (GLPA) / Western Alliance Conferences (WAC) (October 22–26)

Users from five ISIs came together to host an OpenSpace booth at the GLPA/WAC conference. This marked the time staff from OpenSpace Partner institutions and other ISI users represented the project at an OpenSpace booth without AMNH staff, showcasing the growth of community among users and their enthusiasm for sharing their work with peers. Additionally, these users presented six sessions including:

- "Searching for Origins of Life: Utilizing OpenSpace to Connect Ocean and Space Research" - Sarah Treadwell
- "Urban Skies - Equitable Universe: Incorporating Youth Voice Into Programs" - Paulette Epstein, Michigan Science Center
- "Research Collaborations with the OpenSpace" - Dan Tell, Cal Academy
- "Connecting the Dots: A GUI for Custom Constellation Artwork in OpenSpace"- Emily Watson and Sara Schulz, MSUM

OpenSpace users host the OpenSpace exhibition booth at GLPA/WAC.

Academic Publications

M. Brossier, A. Bock, K. Schönborn, T. Isenberg, A. Ynnerman, L. Besançon (2024), *In space, no one (but AI) can hear your scream,* IEEE Visualization.

E. Elmquist, M. Ejdbo, A. Bock, DS. Thaler, A. Ynnerman, N. Rönnberg (2024), *Birdsongification: Contextual and Complementary Sonification for Biology Visualization,* Proceedings of the International Conference on Auditory Displays, 34-41.

Conference Abstracts

C. Emmart, R. Kinzler, A. Bock, Y. Selling, M. Ejdbo, M. Acinapura, M. Villa, V. Trakinski (2023), *Engaging the Public with NASA Data: Ongoing Innovation of OpenSpace*, AGU Fall Meeting 2023, id. ED34A-02.

C. Emmart, R. Kinzler, V. Trakinski, D. S. Ebel (2023), *Producing with Data Visualization to Show the Complexity of Earth Systems*, AGU Fall Meeting 2023, id. SY11D-02

M. Dominguez, J. Keller, M. Acinapura, C. Emmart, A. Bock (2023), Exploring Shadows *Through OpenSpace: Creating 3D Visualizations and Simulations of Solar Eclipses,* AGU Fall Meeting 2023, id. U41B-0852

J. Faherty, B. Abbott, M. Acinapura, A. Bock, C. Emmart (2024), *The OpenSpace planetarium software and its impact on visualizing the Known Universe,* American Astronomical Society, AAS Meeting #243, id. 168.01. Bulletin of the American Astronomical Society, Vol. 56, No. 2 e-id 2024n2i168p01

C. B. Emmart, A. Ynnerman, A. Bock, J. Kilby, A. Ost, T. A. Roseborough, M. S. Robinson (2024) *A Stereographic Dome Production of the Apollo J-Mission Lunar Field Exploration Using LROC Terrain and Spatiotemporal Mapping of EVA Traverses,* 55th Lunar and Planetary Science Conference, LPI Contribution No. 2785.

A. Goodman C. Zucker, J. Faherty, J. Alves, B. Abbott, M. Acinapura, R. Benjamin, G. Edenhofer, C. Emmart, D. Finkbeiner, R. Konietzka, T. O'Neill, A. Saydjari (2024), *MilkyWay3D.org: A 3D Map of the Star Forming Milky Way - for Everyone*, 244th Meeting of the American Astronomical Society, id. 111.01. Bulletin of the American Astronomical Society, Vol. 56, No. 7 e-id 2024n7i111p01

Graduate Theses

OpenSpace continues to be a focus of master student thesis projects at Linköping University; NASA Community Coordinated Modeling Center, Goddard Space Flight Center; New York University and University of Utah. The following theses were submitted in Year Nine:

- Engberg, A. Investigating the Chemical Cartography of the Galaxy Through Visualization (Master's Thesis, American Museum of Natural History). 2023.[9]
- Lundkvist, A. and Salsborn, E. Enhancing Dungey Cycle Visualization in OpenSpace (Master's Thesis, NASA Community Coordinated Modeling Center). 2023.
- Molin, A. and Johnstone, J. Space Weather Simulation Model Integration (Master's Thesis, NASA Community Coordinated Modeling Center). 2023.[10]

Cross-Collaboration with Science Activation Awards

We have had ongoing conversations, development activities, and public programming in collaboration with other SciAct projects.

Cosmic Storytelling with NASA Data

This year, we continued working with the CosmicDS team, largely through outreach with a public program at the American Museum of Natural History (Astronomy Live: Mapping the Milky Way in 3D) and a program for researchers at the Harvard-Smithsonian Center for Astrophysics at the Museum of Science, Boston. We look forward to continuing this collaborative effort into Year Ten.

Smoky Mountains STEM Collaborative

The OpenSpace team provided support to SMSC staff use of the software in their programming.

STEM Enhancement in Earth Science (SEES)

The OpenSpace team hosted an introductory training for SEES mentors. We plan to continue supporting the SEES mentors in their use of OpenSpace with SEEs interns next year.

[9] https://www.diva-portal.org/smash/record.jsf?pid=diva2%3A1889204&dswid=-9172
[10] https://liu.diva-portal.org/smash/record.jsf?pid=diva2%3A1829691&dswid=-6189

Science Through Shadows

In Year Nine, developer Micah Acinapura supported intern work at Fiske Planetarium to implement occultations into OpenSpace. The students will present this work at the AGU 2024 meeting.

Cross-Collaboration with NASA Infrastructure Projects

Museum & Informal Education Alliance

Jeff Nee published an OpenSpace show for educators on NASA CONNECTS. This resource is featured on one of the highest trafficked CONNECTS pages. OpenSpace webinars have also been shared to the public CONNECTS calendar.

NASA's Eyes

We continued to collaborate with Eyes personnel to exchange data, resources, and strategies for covering upcoming mission milestones.

NASA Solar System Treks

This year, OpenSpace continued to integrate terrain layers from NASA Treks into OpenSpace. We are in discussion about developing a more direct pipeline between OpenSpace and Treks developers in Year Ten.

Solar System Ambassadors

Through trainings and one-on-one assistance, the OpenSpace team enabled multiple Solar System Ambassadors to use the software for outreach presentations.

NASA Science Visualization Studio

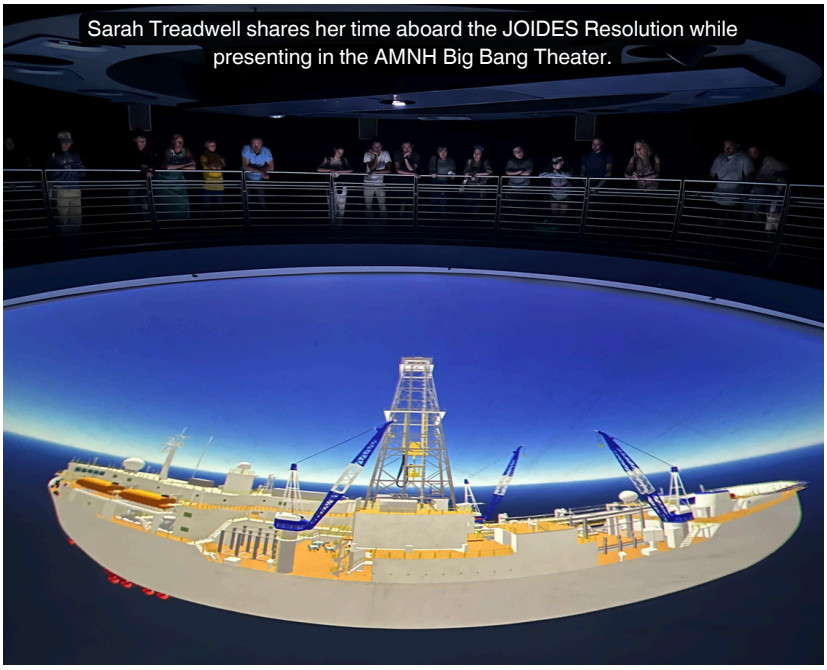
OpenSpace continued to integrate 3D models from NASA SVS into OpenSpace programming. One of our OpenSpace developers visited SVS in June, initiating a discussion about creating an SVS profile in OpenSpace. Part of this work will be to develop a pipeline to bring continuously updated data from SVS's new Earth Information Center directly into OpenSpace to support programming about current climate observations and model outputs in planetarium domes.

In addition to the above formal cross-collaboration agreements, the OpenSpace project team has participated in the Visualization, Rural, Broadening Participation, Diversability, and Learning Communities of Practice as well as the SciAct Communications Backbone group. The following informal collaborations also occurred in Year Nine.

NASA SCoPE

OpenSpace participated in two mission liaison workshops hosted by NASA SCoPE. Additionally, OpenSpace collaborated on three NASA SCoPE seed grants

- Dr. Mark Popinchalk's "Spinning Stars in OpenSpace" project integrated data from the NASA Transiting Exoplanet Space Satellite (TESS) into OpenSpace. Popinchalk presented his work at the Hayden Planetarium to 30 colleagues, family, and friends. He is finalizing the program guide to share with the wider OpenSpace community.
- This year, Sarah Treadwell began work on the "Searching for Origins of Life: The Lost City and Icy Worlds" project to visualize data from the Lost City Hydrothermal Field in OpenSpace. Treadwell presented for 175 museum attendees in AMNH's Big Bang Theater and an additional 20 people in the Hayden Planetarium. She is finalizing her program guide.



Sarah Treadwell shares her time aboard the JOIDES Resolution while presenting in the AMNH Big Bang Theater.

- Abel Méndez, Director of the Planetary Habitability Laboratory and Associate Professor of Physics and Astrobiology at the University of Puerto Rico at Arecibo, submitted the project "Arecibo Wow! Exploring Interstellar Communication," which has been accepted for development in Year Ten. This project will leverage OpenSpace for outreach activities celebrating the 50th anniversary of the Arecibo Message. Stellar maps and data from the Planetary Habitability Laboratory's Habitable Worlds Catalog will also be integrated into OpenSpace.

NASA Astrobiology Guild

During a NASA Astrobiology Guild Webinar, Sarah Treadwell shared OpenSpace's role in communicating complex scientific data to diverse audiences. Her presentation included custom visualizations of the Lost City Hydrothermal Field, inspired by her expedition, and highlighted OpenSpace's potential as a compelling platform for public outreach.

NASA-Funded SMEs

In Year Nine, 30 NASA-funded Subject Matter Experts contributed to and/or used OpenSpace, including nine new SMEs (indicated with an *asterisk). This brings the total number of unique SMEs to 105. The table below describes how each SME utilized OpenSpace; in some instances, SMEs used the software in multiple ways.

Subject Matter Expert	Public Program	Formal Education	For Research	Contributed Data or Code
*Knicole Colón, PhD(Operations Project Scientist, NASA GSFC)	X			
Jason Craig (Visualization Producer, NASA's Eyes)				X
*Bart De Pontieu, PhD (PI, NASA Interface Region Imaging Spectrograph (IRIS))	X			
Darren De Zeeuw, PhD (Research Associate, NASA Goddard Space Flight Center Community Coordinated Modeling Center)				X
Denton Ebel, PhD (Co-I, AMNH)	X			
Mostafa El Alaoui, PhD (Research Associate, NASA Goddard Space Flight Center Community Coordinated Modeling Center)				X
Jackie Faherty, PhD (Sr. Scientist and Sr. Education Manager, Departments of Astrophysics and Education, AMNH)	X	X	X	X
Ben Feist (Software Engineer, Data Visualization & Informatics)				X
*Manolis Georgoulis, PhD (Sr. professional staff at the Johns Hopkins University Applied Physics Laboratory	X			
*Eileen Gonzales, PhD (Assistant Professor at San Francisco State University in the Department of Physics & Astronomy)	X			
Alyssa Goodman, PhD (PI, Harvard University)	X			X
*Kevin Hand, PhD (PI/Director, NASA JPL Ocean Worlds Lab)	X			
*Joel Hurowitz, PhD (Deputy Principal Investigator,Planetary Instrument for X-ray Lithochemistry (PIXL))	X			
John Keller, PhD (PI, ROSES, University of Colorado Boulder)	X	X		
Masha M. Kuznetsova, PhD (Director, NASA GSFC CCMC)				X
Pascal Lee, PhD (Planetary Scientist, NASA Ames Research Center)	X			
Mordecai-Mark Mac Low, PhD (Co-I, AMNH)			X	
Leila Mays, PhD (Deputy Director, NASA GSFC CCMC)	X			X
*Scott Miller (Aerospace Flight Systems Engineer at NASA's Ames Research Center)	X			
Jeff Nee (Education Specialist, NASA Jet Propulsion Laboratory)	X			
Bob Pappalardo, PhD (Project Scientist, NASA Jet Propulsion Laboratory)				X

Subject Matter Expert	Public Program	Formal Education	For Research	Contributed Data or Code
Mark Popinchalk, PhD (NASA SCoPE seed grant awardee)	X			X
Lutz Rastaetter, PhD (Research Assistant, Fields And Particles, NASA GSFC CCMC)				X
*Maria J. Rieke, PhD (PI, Near-Infrared Camera (NIRCam) and Professor Of Astronomy, University Of Arizona)	X			
Rachel Smith, PhD (Co-I, NCMNS)	X	X		
Mark SubbaRao (Lead, NASA SVS)				X
*John Wirzburger (Systems Engineer, Parker Solar Probe)	X			
Ernest T. Wright (Graphics System Specialist, NASA SVS)				X
Alex Young, PhD (Associate Director for Science, Heliophysics, NASA GSFC)				X
Catherine Zucker, PhD (Astrophysicist at the Smithsonian Astrophysical Observatory)	X			X

Other SMEs

An additional (non-NASA) 19 SMEs used OpenSpace as a tool for exploring and communicating Earth and space science data to broad audiences, including nine new SMEs (indicated with an *asterisk). This brings the total of unique (non-NASA) SMEs to 57.

Subject Matter Expert	Public Program	Formal Education	For Research	Contributed Data or Code
*Jennifer Bergner, PhD (Assistant Professor in Chemistry, University of California at Berkeley)	X			
Dan Caton, PhD (Professor of Physics and Astronomy, Director of Observatories, Appalachian State University)	X	X		
*Lorant Czaran (Scientific Affairs Officer, Chief Vienna Branch, UN-SPIDER)	X			
*Samantha Doxtator (Haudenosaunee-Oneida Learning Consultant)	X			
*Carl Fields, PhD (RPF Distinguished Postdoctoral Fellow, Los Alamos National Laboratory)	X			
Marina Gemma, PhD (Planetary Scientist, Department of Earth and Planetary Sciences, AMNH)	X			
*Ariel Marcelo Goobar (Director of Oskar Klein Centre for Cosmoparticle Physics, Stockholm University)	X			
Trent Hare (Cartographer, USGS Astrogeology Science Center)				X

Subject Matter Expert	Public Program	Formal Education	For Research	Contributed Data or Code
James Hedberg, PhD (Director, CCNY Planetarium, City College of New York)	X	X		
Jon Linker, PhD (Senior Research Scientist, Predictive Science)				X
Ed Lu, PhD (Executive Director, the Asteroid Institute, B612 Foundation)			X	
Joachim Moeyens, PhD (Research Software Engineer, University of Washington)			X	X
*Göran Östlin (Professor, Stockholm University)	X			
Lucian Plesea (Web GIS developer, ESRI)				X
Allan Posner (Astrodynamicist, the Asteroid Institute, B612 Foundation)			X	
*Enrico Ramirez-Ruiz, PhD (Professor, University of California, Santa Cruz)	X			
Bob Raynolds, PhD (Research Associate, DMNS)	X			
*Alexandra Tetarenko, PhD (Assistant Professor, University of Lethbridge)	X			
*Wouter Vlemmings (Full Professor, Astronomy and Plasma Physics, Chalmers University of Technology)	X			

V. Evaluation

Evaluation by HG&Co

The OpenSpace project's external evaluator, HG&Co (118 Franklin Street, Concord, NH; 301-655-1925; kate@hgandco.com), collaborated with the AMNH team in Year Nine on three key evaluation activities: a survey assessing audience feedback from public programs, an analysis of communication on Slack, and a survey to evaluate software usage and needs of planetariums nationwide. Further details and updates on these activities are provided in the attached Evaluator Report.

Top-Level Metric Projections

In the initial funding phase, OpenSpace's primary metric for success was the number of interactive NASA data "profiles" integrated into the software. For Phase II, we transitioned to measuring project growth by tracking the number of active OpenSpace users, aiming to reach 100 institutions by Year 10. As Year Nine concludes, the OpenSpace community has achieved this milestone with 102 active users.

SciAct Alignment

The OpenSpace leadership team collaborated with the evaluator to align the project with the SciAct portfolio-level activities led by PRE. This collaboration ensured alignment with mid-level objectives and identified specific program indicators corresponding to these objectives.

OpenSpace is currently aligned with SciAct MLOs 1b, 1c, and 3c:

1b) Provide opportunities for participants to engage with the disciplinary content related to NASA science and engineering.

1c) Increase the number of and frequency with which NASA SMD assets are used by learners across the US.

3c) Engage participants in learning experiences that promote development of skills for STEM careers.

(1b, 1c) This report highlights OpenSpace's goal to broaden public engagement with NASA's science and engineering through Informal Science Institution (ISI) initiatives tailored for all age groups. In Year Nine, OpenSpace was used in over 1,355 programs and 10 exhibits to communicate scientific and engineering concepts, with 169 of these events delivered by the OpenSpace ISI Partner Network supported by NASA SciAct funding. To date, OpenSpace has driven a cumulative total of 2,340 programs. This year alone, these programs and exhibits reached 1,048,058 individuals on-site, bringing total on-site engagement to 3.5 million.

(1b, 1c) This year, online engagement saw a decrease but continued to play a significant role, with audiences accessing live sessions, recorded programs, and curated video content. Approximately 9.7 million individuals were reached online through OpenSpace, escalating the total online engagement to over 76 million. Moreover, through the OpenSpace website and its social media channels, the digital outreach further expanded by more than 650,000, elevating the overall digital footprint of OpenSpace owned content to exceed 6.6 million.

(1b, 1c, 3c) In Year Nine, the OpenSpace funded partners hosted 30 interns, spanning from high school to undergraduate levels, across diverse durations including multi-week and semester-long internships. These interns received mentorship in data visualization and code development. Non-funded ISI users hosted four interns working with OpenSpace. To date, 290 internships have utilized OpenSpace.

Year	NASA SMEs	ISIs and other organizations	Programs	On-site reach	Online reach	Other online reach
Y9	30[11]	102 [12]	1,355	1,048,058[13]	9,775,590[14]	656,446[15]
Y1-9 Total	**106**	**116**	**2,340**	**3,548,144**	**76,733,902**	**6,629,708**

[11] Nine of the NASA-funded SMEs are new in Year Nine.
[12] 13 of the public institutions are new to the project in Year Nine.
[13] On-site reach includes programs and exhibition experiences on-site at funded and non-funded ISIs and other public institutions.
[14] Online reach includes views of online programs, recordings of these programs, and produced videos.
[15] Other online reach includes visits to the OpenSpace website, the reach of OpenSpace social media, and views of OpenSpace content.

VI. Known Future Plans

A key goal for Year Ten is to expand and strengthen our user community. We plan to focus on addressing obstacles that hinder or deter a diverse user base from adopting the software, including the launch of OpenSpace Cloud. Additionally, we plan to continue to incorporate new data sets to offer a broader range of programs aligned with NASA's ongoing science and mission activities.

Software and Content Development Goals

Software and content development activities planned for Year Ten include:

- Implement accessible user interface recommendations
- Develop Ancillary materials
  - Documentation
  - Program guides
  - Training videos
- Pilot *OpenSpace Cloud* in the context of three different use cases: the B612 Foundation,Cosmic Storytelling with NASA Data, and the Community Coordinated Modeling Center at NASA Goddard

ISI Partner Network Goals

ISI Partner Network programs planned for Year Ten include:

- Astronomy Days (January 2025, NCMNS)
- OpenSpaceFest (January 2025, California Academy of Sciences): a weekend workshop series for local ISI professionals
- OpenSpace User Meeting (August 2025, AMNH): the first annual community meeting of OpenSpace ISI and individual users. This two-day meeting will include trainings on the latest OpenSpace features, presentations from individual users. This event has been requested from our users to receive hands-on training and network with their peers in-person.

ISI Partner Network Goals

ITo support existing users and encourage further adoption of the software, we are planning the following dissemination activities for Year Ten:

- Develop and distribute additional online resources for users, developers, and scientists, including tutorial videos, program guides, and training materials
- Attend and present at AGU (December 2024) in eight sessions:
  - ED035: Science Activation Brings NASA Earth and Space Science to New Audiences
  - SA023 - The MacGyver Session: The Place for Novel, Exciting, Self-Made, Hacked, or Improved Sensors and Software Solutions for the Year of Open Science and the Heliophysics Big Year
  - ED039 - Undergraduate Earth, Atmospheric, Ocean, And Space Science Research And Outreach Posters
  - IN13D - Planet Building: Advances in Data Visualization Methods and VR/AR/MR Spatial Interface Systems to Support Earth and Space Science II Oral
  - ED029 - Museums and Planetariums as Innovative Communication Hubs for Earth and Space Sciences
  - ED012 - Digital Learning Innovation in Earth and Space Science Education: Promises, Pitfalls, and the Path Ahead
  - SY052 - Sharing Their Science: Enabling Scientists in Public Engagement and Communication Efforts
  - SY018 - Data Visualization as a Communication Tool in the Earth and Space Sciences
- Develop dissemination strategy pertaining to the following conferences:
  - AAS (January 2025)
  - LPSC (March 2025)
  - Elumenati GeoDome Network Meeting (May 2025)
  - AAS (June 2025)
  - ASTC (September 2025)
  - GSA (October 2025)
  - AGU (December 2025)

VII. Appendix - OpenSpace Profiles

These profiles are available for every OpenSpace user and do not include any custom profiles created by users.

Apollo: This profile contains models and trajectories for the NASA Apollo 8 mission circling the Moon, including when the iconic “Earthrise” image was photographed. It also contains additional datasets showing the landing sites of Apollo 11 and 17, and photogrammetry of boulders from Apollo 17 station sites.

Artemis: This profile visualizes NASA’s Artemis 1 mission. The profile starts focusing on the Artemis I Orion spacecraft as it approaches the Moon on Monday, November 21, 2022. An updated Mission user interface allows the user to jump to relevant mission milestones.

Asteroids: More than 936,000 asteroids and comets from JPL Horizons Small-Body Database, including: Amor Asteroids, Apollo Asteroids, Aten Asteroids, Atira Asteroids, Centaur Asteroids, Chiron-Type Comets, Encke-Type Comets, Halley-Type Comets, Inner Main Asteroid Belt, Jupiter Family Comets, Jupiter Trojan Asteroids, Main Asteroid Belt, Mars Crossing Asteroids, Outer Main Asteroid Belt, Potentially Hazardous Asteroids, and Trans-Neptunian Asteroids.

Bastille Day 2000: This profile shows the Coronal mass ejection (CME) that occurred on Bastille Day, July 14, 2000. The visualizations to highlight the CME include: a volume rendering of the density of the material ejected from the sun; field lines showing the Sun’s magnetic structure; magnetograms which are texture layers on the sun showing variation in strength of the magnetic field; an extreme ultraviolet (EUV) image sequence layer shown on the sun; a light speed indicator to compare the speed of the CME; cut plane sequences showing the flux values of the CME, one equatorial cut plane and one meridional. Also there are flux nodes that show flux values, which are accompanied by a legend describing the color scheme.

BepiColombo: This profile shows the spacecraft and trajectory of ESA’s BepiColumbo as it is continuing the discovery process started by the MESSENGER mission. The data for this profile was the result of a collaboration with ESA’s SciFleet and the ESA SPICE Service.

Dawn: This profile contains a 3D model and trajectory of the NASA Dawn spacecraft, and bodies and trajectories for Ceres and Vesta.

Default and Default Full: This profile is enabled on default and provides the ability to look at detailed terrain models of the Earth, Moon, Mars, other planets, and the Digital Universe extrasolar catalog. Default Full has more optional content, including Earth satellites and more moons in our solar system.

Eclipses: This profile includes assets to support telling stories about eclipses. The profile starts focused on Earth with umbral and penumbral shadow cones visible. Additional information on eclipses and an interactive timeline of eclipses in the last century and for the next century are available in the Missions user interface.

Empty: This profile does not contain any graphics and is to be used to visualize the user's own 3D models or datasets.

Euclid: This profile shows the trajectory and spacecraft model of ESA's Euclid mission that has has its goal to observe billions of galaxies and provide more information about the large-scale structure of our universe. The data for this profile was the result of a collaboration with ESA's SciFleet and the ESA SPICE Service.

Gaia: This profile contains a new rendering method to show the dataset from ESA Gaia's Data Release 2 (DR2). By default, it loads 7.224 million stars of the Gaia DR2 that contain radial velocities.

Juno: This profile shows a model and approach of the NASA Juno space probe to the Jupiter system and its initial orbits around the gas planet in July 2016. Future work will include visualization of the Juno cam imaging.

James Webb Space Telescope: This profile visualizes the NASA-ESA-CAN James Webb Space Telescope, which launched on December 25, 2021. The profile includes two visualizations of the Webb trail: One plotted with respect to the Earth-Sun L2, where it will be stationed; and another with respect to the Sun, as we plot the orbits of the planets. The profile includes a dynamic model of Webb and a time lapse of its deployment and unfolding. The profile includes the capability to point the telescope with an associated view frustum to any celestial coordinates. The orientation can be controlled by entering Right Ascension (R.A.) and Declination (Dec.) on an external webpage.

Mars: This profile adds visualizations for the NASA Interior Exploration using Seismic Investigations, Geodesy and Heat Transport (InSight) mission, including a trajectory towards Mars, model of lander, entry into the Martian atmosphere, and subsequent descent and landing on November 26, 2018; and NASA's Mars 2020 mission, including a trajectory and model of Perseverance rover on the surface.

Messenger: This profile contains a model and trajectory of the NASA MESSENGER spacecraft with craft pointing data from March to June 2011. In addition, a rendering of Mercury's magnetosphere based on data recorded by MESSENGER can be enabled and viewed around the planet. Along with the mission data, additional maps were added to Mercury showing element abundances on the surface and a multi-color mosaic from the Mercury Dual Imaging System (MDIS) instrument.

New Horizons: This profile shows the acquisition of NASA New Horizons' images of the Plutonian system in July 2015. The profile starts at around 10:00 GMT on July 14, about 10 minutes before a new image campaign starts. By selecting Pluto as the Focus and moving time faster, you can see the imprint of the instrument's field-of-view on the planetary surface and see the images being projected. A timer on the top left of the screen shows when the next image is being taken.

Night Sky: This profile visualizes the night sky from Earth. The profile starts on Earth, with a camera view of the horizon and night sky. Users can adjust the date and time settings to view the sunrise and sunset.

Offline: This profile includes low resolution maps of planets that do not require internet connection.

OSIRIS-REx: This profile demonstrates the entire lifetime of the NASA OSIRIS-REx (Origins, Spectral Interpretation, Resource Identification, Security, Regolith Explorer) spacecraft on its way to the 101955 Bennu asteroid and its subsequent journey back to Earth. The profile starts at Earth before the spacecraft's launch and has information throughout the entire mission until the sample's 2023 landing back in Utah. Models of OSIRIS-REx and Bennu are available, as well as a preliminary instrument timing and some of the imaging campaign, which uses the same projection technique as employed in the New Horizons and Rosetta profiles.

Rosetta: This profile shows the entire mission of the ESA Rosetta spacecraft around comet 67P, also known as Churyumov-Gerasimenko. The spacecraft's images are projected onto the comet and the separation of the Philae lander is visible as well.

Solar Storm 2012: This profile, created in collaboration with NASA GSFC's Community Coordinated Modeling Center (CCMC), shows several coronal mass ejections (CMEs) during July 2012.The interaction of the flow of the solar wind and Earth's magnetosphere is simulated by CCMC's Bats-R-US code, and the ENLIL real-time solar wind application is used as a volumetric dynamic simulation visualization. There is also a one time step of the PFSS model showing the Sun's local magnetic structure.

Touch: This profile provides five demonstration experiences for a Windows touch table: Explore the galaxies, explore the solar system, explore Jupiter and its moons, explore weather events on Earth, and explore interesting sites on Mars. These experiences were created by students as examples. OpenSpace users can create their own experiences with the content they would like to show.

Voyager: This profile contains the NASA Voyager 1 and Voyager 2 missions as they were launched from Earth in the 1970s and observed the gas giants in the solar system. The spacecraft models are included and are pointed accurately throughout the mission. Position and orientation information are available until the second half of the 21st century.

VIII. Appendix - Evaluation Reports

OpenSpace Year Nine Summary Evaluation Report

OpenSpace Year 9:

End-of-Year Evaluation Report

October 30, 2024

Project Background

The OpenSpace project (full name: *OpenSpace: An Engine for Dynamic Visualization of Earth and Space Science for Informal Education and Beyond*) designs, builds, and disseminates the OpenSpace open-source software for visualizing NASA astrophysics, heliophysics, planetary science, and Earth science mission activities, data, and simulations. Through partnerships with Informal Science Institutions (ISIs), SMD missions and scientists, and academic researchers, the project engages a broad spectrum of the American public in the excitement and science behind our ongoing search to understand the universe and our place within it.

American Museum of Natural History (AMNH) is the lead organization, with Dr. Rosamond Kinzler serving as Principal Investigator. Funded Informal Science Institution partners from SciAct 1.0 and SciAct 2.0 are: The Adler Planetarium, California Academy of Sciences (CalAcademy), Denver Museum of Nature and Science (DMNS), Houston Museum of Natural Science (HMNS), and North Carolina Museum of Natural Sciences (NCMNS). Software development partners include New York University Tandon School of Engineering, University of Utah's Scientific Computing and Imaging Institute, and Linköping University's Science Visualization Group in Sweden.

HG&Co, a nationally known visitor-centered planning, strategy, and evaluation firm serves as the external evaluator for the OpenSpace project. Kate Haley Goldman is the project's lead evaluator, supported by Madeleine Pope, Lesley Henry Kadish, and María Sotomayor.

Building on the successful grant activities to date, the project continues to engage its highly qualified team of scientists, educators, software engineers, and visualization specialists in order to:

- **Continue development of OpenSpace** open-source software as a robust pipeline for transmitting visualized science content from across NASA SMD divisions to ISIs and the general public.
- **Continue to feed the pipeline** with visualized content by partnering with NASA SMEs and enhancing the software to further enable scientists and other individuals outside the core OpenSpace team to develop and contribute content.
- **Broaden dissemination, adoption, and implementation** of OpenSpace among ISIs.
- **Increase Diversity, Equity, Inclusion, and Accessibility (DEIA)** through internships, and across audiences.
- **Enhance collaborations** with SciAct projects, Infrastructure and NASA SMEs.

The project's leadership team worked with HG&Co to identify the following measurable project outcomes:

- Increased use of OpenSpace by ISIs, NASA SMEs, and SciAct projects
- Increased participation of NASA SMEs in public outreach
- Increased understanding of the process of NASA research activities and science outcomes among public audiences
- Increased access to and engagement with NASA SMD assets by populations underrepresented in STEM
- Student engagement in 21st Century skills via NASA SMD assets

The OpenSpace evaluation team has gathered significant amounts of data towards both formative and summative questions identified at the beginning of the SciAct 2.0 funding period. At this stage of the work, the OpenSpace project is increasingly focused on growth of the overall network of users for the OpenSpace software. In support of the project team, the evaluation work in Year 9 (2024) focused on the following questions:

1. Does using OpenSpace increase interest and engagement in SMD content and STEM learning?
2. Is the network effectively supported? Is it growing?
3. Does OpenSpace increase access to, and use of, space-related scientific visualizations by ISIs and others?

Study Overview and Goals

The OpenSpace project is fundamentally about increased access to and impact of Earth and space-themed scientific visualizations. This work builds on the enormous amount of SMD data and expertise, creating a tool that allows both the public and the scientific community to view and explore what is known about Earth and space.

In Year 9, we focused evaluation on how the OpenSpace network of users is growing. These critical formative and summative evaluations, linked directly to the SciAct 2.0 mid-level objectives 1B[1] and 1C[2], led the evaluation team to (a) expand the use of our Public Program Audience Survey to additional locations to measure the impact of OpenSpace visualizations, (b) plan a network analysis of peer-to-peer support and collaboration on the project's public Slack channel, and (c) examine programming and workflow—as well as awareness and use of OpenSpace—in planetariums across the United States as a

[1] MLO 1B is "Provide opportunities for participants to engage with the content related to NASA science and engineering."
[2] MLO 1C is "Increase number of and frequency with which NASA SMD assets are used by learners across the US."

way to gauge potential growth. Each of these three studies are described in more detail below. The findings will be communicated in future reports.

A. Expansion of Public Program Survey

Does using OpenSpace increase interest and engagement in SMD content and STEM learning?

We have collected evaluation data from public programs at each of the funded ISI partner sites for every year of SciAct 2.0, and while we continue to provide an incentive for completion of the surveys, our response rates fell as some ISIs lost the ability to do as many virtual public programs as they had earlier in the project, and the team concentrated on other priorities. This year, we redoubled our efforts on survey completion at the five funded ISI partners, and expanded surveys to other frequent users of OpenSpace within the network. Individuals who completed the survey were given the opportunity to provide a mailing address to receive an OpenSpace sticker.

This survey (both in years past as well as in Year 9) supports MLO 1B by tracking the public programs hosted by ISI sites--on-site and online--that engage participants in NASA-related science content. This year, in addition to the six funded ISI partners who are long-term participants, we invited fifteen new ISIs and formal learning sites to use the Public Program Survey with their OpenSpace audiences, thus supporting MLO 1C. In thanks for their support, we offered to share all data collected from their audiences with these institutions, and to include a site-specific question of their choosing. Of those fifteen sites, six accepted the offer and have taken steps towards collecting data with this instrument. Those are:

- Lawrence Hall of Science in Berkeley, CA
- Lower Eastside Girls Club in New York, NY
- Michigan Science Center in Detroit, MI
- Towson University in Towson, MD
- University of Nebraska State Museum Ralph Mueller Planetarium in Lincoln, NE
- Versant Power Astronomy Center at University of Maine in Orono, ME

One site, the University of Nebraska State Museum, requested an additional version of the survey for teachers who bring their classes to the Planetarium, with additional questions about how engaging the program was to the students from the teachers' perspectives.

Five more sites are on hold but interested in using the survey when they have capacity and/or programming to implement it; for most this is later in 2024 or early in 2025. Those are:

- Fiske Planetarium in Boulder, CO
- Mayo High School in Rochester, MN
- Museum of Life and Science in Durham, NC
- Southwest Minnesota State University Planetarium in Marshall, MN

- Springfield Science Museum Seymour Planetarium in Springfield, MA

We also launched a Spanish-language version of the survey to explore demand for translation into the second most-commonly spoken language in the United States, according to the U.S. Census. We provided the Spanish and English versions to each site as links (for use in follow-up emails) and QR codes (to post around the physical space).

The online, 24-question survey with skip logic is linked through SurveyMonkey, and takes an average of 12 minutes to complete. In Year 9 so far, we have received 688 responses, 96% of which are from AMNH visitors. The status and number of surveys received from each site are below.

Institution or Organization	NASA-funded	Participation status	Surveys in 2024 (n=688 total)	% of total surveys so far
Adler Planetarium	Yes	On hold	1	0.1%
AMNH	Yes	Collecting	660	95.9%
CalAcademy	Yes	Collecting	5	0.7%
DMNS	Yes	On hold		
Fiske Planetarium	No	On hold		
HMNS	Yes	On hold		
Lawrence Hall of Science	No	Collecting	9	1.3%
Lower Eastside Girls Club	No	Preparing to collect		
Mayo High School	No	On hold		
Michigan Science Center	No	Preparing to collect		
Museum of Life and Science	No	On hold		
NCMNS	Yes	On hold	1	0.1%
Southwest Minnesota State University Planetarium	No	On hold		
Springfield Science Museum	No	Preparing to collect		
Towson University	No	Collecting	1	0.1%
Univ. of Nebraska State Museum-Mueller Planetarium	No	Collecting	11	1.6%
Versant Power Astronomy Center, University of Maine	No	Preparing to collect		

Seventy-four stickers have been requested by online survey respondents this year--a smaller number than last year. This may have to do with a couple of factors: 322 surveys for AMNH were completed in-

person where incentives are handed out directly, and sticker requests dropping off after switching from NASA to OpenSpace stickers.

Both the English and Spanish versions of this survey are in the Appendices (A and B). We will report on the findings for this study once enough data have been recorded (for sites other than AMNH).

B. Slack analysis of peer-to-peer support and collaboration

Is the network effectively supported? Is it growing?

Our past Collaboration Surveys and Network Surveys have shown that Slack is the primary mode of support and the preferred method of communication for both funded partners and the larger network of contributors and users. To better understand if users are supported and if the network is growing, a Slack analysis of peer-to-peer support and collaboration is underway. Slack metadata allows for a social network analysis of patterns over time, including increased use, peer-to-peer communications, and nodes of engagement.

This analysis supports MLOs 1B and 1C as it will inform the dissemination, adoption, and implementation of OpenSpace among ISIs and continue to feed the pipeline with visualized content. The analysis will begin in December 2024 and be reported on in 2025.

C. Survey of Dome Sites in the United States

Does OpenSpace increase the access to, and the use of, Earth and space-related scientific visualizations by ISIs and others?

In order to better understand the ways in which OpenSpace adoption could be increased, we have designed a survey to send to dome-based professionals in the United States, asking about their workflow and current programming strategies. By hearing about aspects of their work, such as whether or not these professionals do live presentations, create new programs around current science, and turn data into visualizations, the team will gain a better sense of how OpenSpace could support these processes and potentially expand the range of dome programming– especially at institutions with small budgets in which a free and open-source software might be especially impactful, thus supporting MLOs 1B and 1C.

Through a list of dome-based professionals acquired through Loch Ness Productions, we have approximately 700 email addresses of individuals across 150 American informal learning institutions and 220 colleges or universities. These individuals will be sent the SurveyMonkey survey via direct email from the OpenSpace team. We believe that many of these professionals will be responding out of an interest in bettering their professional field, so we are offering the incentive of a $5 donation to their choice of either the Astronomical Society of the Pacific (an “international non-profit scientific and educational organization that works to increase understanding and appreciation of astronomy”) or

International Dark Skies (which “raises awareness about light pollution and offers strategies for outdoor lighting to address light pollution”).

Now near finalization of the survey instrument, the team is preparing to email this survey out to the 700 recipients. The existing draft includes thirteen questions about workflow, programming, and how the respondent entered the field, which will inform the team about how to engage future dome professionals with OpenSpace at pre-career stages. Fifteen more questions explore the respondent’s familiarity with OpenSpace, or (if unfamiliar with OpenSpace) there are ten alternate questions gauging their interest and recording their questions or concerns about trying out the software. The remaining eight questions are for demographics and final thoughts.

This instrument is Appendix C. The data will be reported on in 2025.

Appendix A: Public Program Survey in English

Public Program Survey (OpenSpace 2024, extended)

We're so glad you attended today's program. Thank you for participating in our short survey!

* 1. **Which institution hosted the program**, either in-person or virtually? *(Select one)*

* 2. **Did you see this program in-person or online?** *(Select one)*

- ◯ In-person
- ◯ Online

Online Programs

* 3. **On which platform did you watch the program?** *(Select one)*

- ◯ Facebook
- ◯ YouTube
- ◯ Zoom
- ◯ Other (please specify)

* 4. **Where were you when you watched this program?**

City:

State/Province:

Country *(if not USA)*:

In-person Programs

* 5. **Where did you see this program?** *(Select one)*

- ◯ In a planetarium dome at a museum
- ◯ In a theater at a museum
- ◯ On an exhibit kiosk or screen at a museum
- ◯ In a portable dome somewhere other than a museum
- ◯ Other (please specify):

General Questions

* 6. **On what date did you see this program?**

Date / Time

Date

MM/DD/YYYY

* 7. **Did you enjoy this program?** *(Select one)*

1 Not at all	2 Only a little	3 Somewhat	4 Mostly	5 Very much
◯	◯	◯	◯	◯

* 8. **How much do these words describe the program?** *(Select one in each row)*

	1 Not at all	2 Only a little	3 Somewhat	4 Mostly	5 Completely
Awe-inspiring	◯	◯	◯	◯	◯
Boring	◯	◯	◯	◯	◯
Surprising	◯	◯	◯	◯	◯
Real science	◯	◯	◯	◯	◯
Difficult to Understand	◯	◯	◯	◯	◯
Nothing new	◯	◯	◯	◯	◯
Exciting	◯	◯	◯	◯	◯

* 9. **Did the program help you understand how scientists gather information about Earth or other objects in space?** *(Select one)*

1 Not at all	2 Only a little	3 Somewhat	4 Mostly	5 Very much
◯	◯	◯	◯	◯

* 10. We're interested in people's reactions to the Earth and space visualizations in the program. **How much did the visualizations contribute to your understanding of the project?** *(Select one)*

1 Not at all	2 Only a little	3 Somewhat	4 Mostly	5 Very much
◯	◯	◯	◯	◯

* 11. **Did this program make you more interested in learning about NASA's science and mission activities?** *(Select one)*

1 Not at all	2 Only a little	3 Somewhat	4 Mostly	5 Very much
◯	◯	◯	◯	◯

* 12. **Who did you attend the program with?** *(Select all that apply)*
I attended...

- ☐ On my own.
- ☐ With my family.
- ☐ With my significant other.
- ☐ With my friends.
- ☐ With my class or camp.
- ☐ With my roommates.
- ☐ Other (please specify):

* 13. **Did you attend the program in any of the following roles?** *(Select all that apply)*

- ☐ Teacher
- ☐ Student
- ☐ Parent / Caregiver
- ☐ Other (please specify):
- ☐ Science enthusiast
- ☐ Museum member
- ☐ None of these

14. What aspects of this program **worked especially well** for you?

15. What aspects of this program **did not work well** for you?

16. Do you have any **suggestions for future programs**?

Demographics

We're almost done! Please help us improve future programs by answering a few questions about yourself. You always have the option to select "Prefer not to say."

We ask these to learn more about our audiences and who we are serving with public programs.

* 17. **What is your ZIP code?** *If you prefer not to say, write "00000" below.*

* 18. **Please tell us your age range.** *(Select one)*

- ◯ Under 12
- ◯ 12 - 17
- ◯ 18 - 24
- ◯ 25 - 34
- ◯ 35 - 44
- ◯ 45 - 54
- ◯ 55 - 64
- ◯ 65 - 74
- ◯ Over 75
- ◯ Prefer not to say

* 19. **With which of the following group(s) do you identify?** *(Select all that apply)*

- ☐ American Indian, Native American, or Alaskan Native
- ☐ Asian, Filipino, or Asian American
- ☐ Black, African American, or African
- ☐ Hispanic, Latino/a/x/e, Chicano/a/x/e, or Latin American
- ☐ Native Hawaiian or Pacific Islander
- ☐ White or Caucasian
- ☐ Prefer not to say
- ☐ A race or ethnicity not listed:

* 20. **With which of the following do you identify?** *(Select all that apply)*

- [ ] Female or Woman
- [ ] Male or Man
- [ ] Non-binary or genderfluid
- [ ] Trans or transgender
- [ ] Prefer not to say
- [ ] A gender not listed:

21. **Anything else you'd like to share with the program team?**

22. **If you would like to receive information about future programs**, please enter your email. *(Optional)*

23. **If you would like to receive an OpenSpace sticker in the mail**, please enter your address below as it should be written on the envelope. *Incomplete addresses can not be used! (Optional)*

Name as it should appear on envelope:

Full address for envelope:

Country (if not USA):

Appendix B: Public Program Survey in Spanish

Encuesta sobre Programas Públicos (OpenSpace, ampliado, español)

Esperamos que haya disfrutado del programa de hoy. ¡Gracias por participar en esta encuesta!

* 1. ¿**Qué institución organizó el programa**, ya sea en persona o virtualmente? *(Elija uno)*

* 2. **¿Vio este programa en persona o virtualmente?** *(Elija uno)*

- ◯ Virtualmente
- ◯ En persona

---

* 3. **¿En qué plataforma vio este programa?** *(Elija uno)*

- ◯ Facebook
- ◯ Youtube
- ◯ Zoom
- ◯ Otro (por favor especifique):

* 4. **¿Dónde estaba cuando vio este programa?**

Ciudad:

Estado:

País *(si no es Estados Unidos)*:

---

* 5. **¿Dónde vio este programa?**

- ◯ En el planetario de un museo.
- ◯ En el teatro de un museo.
- ◯ En una exhibición o una pantalla de un museo.
- ◯ En una bóveda portátil fuera de un museo.
- ◯ Otro (por favor especifique):

* 6. **¿En qué fecha vio este programa?**
(MM/DD/YYYY)

Fecha

Date

MM/DD/YYYY

* 7. **¿Disfrutó del programa?** *(Elija uno)*

1 Para nada	2 Solo un poco	3 En cierto modo	4 En su mayoría	5 Mucho
○	○	○	○	○

* 8. **¿Cuánto estas palabras describen el programa?** *(Elija uno en cada fila)*

	1 Para nada	2 Solo un poco	3 En cierto modo	4 En su mayoría	5 Completamente
Impresionante	○	○	○	○	○
Aburrido	○	○	○	○	○
Sorprendente	○	○	○	○	○
Ciencia de verdad	○	○	○	○	○
Difícil de entender	○	○	○	○	○
Nada nuevo	○	○	○	○	○
Emocionante	○	○	○	○	○

* 9. **¿El programa le ayudó a entender cómo los científicos reúnen información sobre el planeta Tierra u otros objetos en el espacio?** *(Elija uno)*

1 Para nada	2 Solo un poco	3 En cierto modo	4 En su mayoría	5 Mucho
○	○	○	○	○

* 10. Nos interesan sus reacciones en cuanto a las visualizaciones del programa sobre el planeta Tierra y el espacio. **¿Cuánto contribuyeron estas visualizaciones para su entendimiento de este tema?***(Elija uno)*

1 Para nada	2 Solo un poco	3 En cierto modo	4 En su mayoría	5 Mucho
○	○	○	○	○

* 11. **¿El programa le creó más interés en aprender sobre la ciencia de NASA y las actividades de sus misiones?***(Elija uno)*

1 Para nada	2 Solo un poco	3 En cierto modo	4 En su mayoría	5 Mucho
◯	◯	◯	◯	◯

* 12. **¿Con quién asistió al programa?** *(Elija todos los que correspondan)*

Asistí...

- ☐ Por mi cuenta.
- ☐ Con mi familia.
- ☐ Con mi pareja.
- ☐ Con mis amistades.
- ☐ Con mi clase o campamento.
- ☐ Con mis compañeros de apartamento.
- ☐ Otro (por favor especifique):

* 13. **¿Asistió a este programa en alguno de los siguientes roles?** (*Elija todos los que correspondan.)*

- ☐ Maestro
- ☐ Estudiante
- ☐ Padre, Madre o Cuidador
- ☐ Entusiasta de la ciencia
- ☐ Miembro del museo
- ☐ Ninguno de estos
- ☐ Otro (por favor especifique):

14. ¿Qué partes del programa funcionaron **especialmente bien** para usted?

15. ¿Qué partes del programa **no funcionaron** para usted?

16. ¿Tiene algunas sugerencias para programas futuros?

Preguntas demográficas

Casi terminamos! Por favor ayúdenos a mejorar programas futuros contestando unas preguntas sobre usted. Siempre tiene la opción de elejir "Prefiero no decir."

Preguntamos esto para aprender más sobre nuestro público y quién asiste nuestros programas.

* 17. **¿Cuál es su código postal?** *Si prefiere no decir, escriba "00000" abajo.*

* 18. **Por favor comparta su rango de edad:** *(Elija uno)*

- ◯ Menos de 12
- ◯ 12 - 17
- ◯ 18 - 24
- ◯ 25 - 34
- ◯ 35 - 44
- ◯ 45 - 54
- ◯ 55 - 64
- ◯ 65 - 74
- ◯ 75 +
- ◯ Prefiero no decir

* 19. **¿Con cuáles de los siguientes grupos se identifica?** *(Elija todos los que correspondan)*

- ☐ Indio Americano, Nativo Americano o Nativo de Alaska
- ☐ Asiático, Filipino o Asiático Americano
- ☐ Negro, Afroamericano o Africano
- ☐ Hispano, Latino/a/e o Chicano/a/e
- ☐ Nativo hawaiano or Isleño del Pacífico
- ☐ Blanco o Caucásico
- ☐ Prefiero no decir
- ☐ Una raza o grupo étnico que no está listado:

* 20. **¿Con cuáles de los siguientes se identifica?** *(Elija todos los que correspondan)*

- [ ] Mujer o Femenina
- [ ] Hombre o Masculino
- [ ] No-binario o género fluido
- [ ] Trans or transgénero
- [ ] Prefiero no decir
- [ ] Un género que no está listado:

21. **¿Hay alguna otra cosa que le gustaría compartir con el equipo que desarrolla estos programas?**

22. **Si le gustaría recibir información sobre programas en el futuro,** por favor introduzca su correo electrónico. *(Voluntario)*

23. **Si le gustaría recibir una pegatina de OpenSpace en el correo, por favor introduzca su dirección física.** *¡Direcciones incompletas no se podrán usar! (Voluntario)*

Nombre:

Dirección completa para un sobre:

País *(si no es los Estados Unidos)*:

Appendix C: Survey of Dome Sites in the United States

Q#	Question	Response Options
S1	**To get us started, how many different organizations or institutions with domes do you work with?**	• 1 • 2 • 3 • 4 or more
S2	**Where is the dome where you work the most often?**	*City, State, Zip Code*
S3	**What is the name of this institution or organization where the dome(s) are?** (Optional but encouraged)	*Open ended*
S4	**What type(s) of dome(s) does that institution use?** Select all that apply.	1. Planetarium dome 2. 3D Theater 3. Portable dome 4. Inflatable dome 5. We do not have any domes at this institution. 6. Other: ____
S5	**What is your job title in this institution?**	*Open ended*
S6	**What space visualization-specific software do you use for this role?** Select all that apply.	1. DarkMatter 2. Digistar 3. Nightshade 4. OpenSpace 5. SkyExplorer 6. Stellarium 7. UniView 8. Other: _____
S7	**How often, if at all, do you do the following tasks in this role**? [*MATRIX: Never, I have once or twice, I have done this occasionally, I have done this frequently.]*	1. Conceptualize new shows. 2. Add data into planetarium software. 3. Create presentation panels / pages. 4. Create session recordings from planetarium software. 5. Provide narration during live presentations. 6. Drive/fly/choose where to take the audience during live presentations.

		7. Provide narration during recorded presentations. 8. Run recorded presentations with recorded narration. 9. Other: _____
S8	*(If conceptualizing new shows)* **Where do you get the ideas for these shows?**	*Open-ended*
S9	*(If creating assets)* **Where do you get the data you use for creating assets?**	1. NASA 2. NSF 3. ESA 4. Research papers 5. Visiting presenters 6. Other: _____
S10	*(If using assets to create shows)* **Where do you source those assets?**	1. NASA 2. ESO 3. Other user-generated content 4. Other: _____
S11	*(If using pre-made shows)* **Where do you source those shows?**	1. Digistar 2. Uniview 3. Other: _____
S12	Now we're going to talk about how you got into this work. **Did you study astronomy, space and Earth science, or a related field in a formal education institution?**	1. Yes 2. No **If not, how did you get into this work?** 1. Hobbyist or self-learning 2. Informal education (mentorship) 3. Other: _____ **If so, what level(s) did you study it at? Select all that apply.** 1. High School 2. College or University 3. Graduate School 4. Doctorate level 5. Other: _____
S13	**Did you get a degree in the field of space and Earth science?**	1. Yes 2. No **If so, what is the name of your degree(s)?** _____

OpenSpace-specific questions		
Q1	**Had you heard about OpenSpace data visualization software before responding to this survey?**	1. Yes 2. No **(SKIP to Route B)** 3. I'm not sure
Q2	*(If Yes or I'm not Sure)* **To the best of your memory, where did you first hear about OpenSpace?** Select one.	1. From a colleague or friend (word-of-mouth) 2. From a professional organization or conference 3. From a professional publication, association magazine, or newsletter 4. From social media 5. Other: _____ 6. I really can't recall.
Q3	*[If "In the dome where I work"]* **To the best of your knowledge, who else is using OpenSpace within this institution?** Select all that apply.	1. Nobody other than me 2. Educators: formal setting (schools, universities, etc.) 3. Educators: informal setting (museums, community spaces, public organizations, etc.) 4. Planetarium professionals 5. Researchers: academic or institutional 6. Researchers: hobbies or personal use 7. SciAct collaborators 8. Scientists 9. Students 10. Other individual or option not listed: _____
Q3a	**Where does this institution display OpenSpace content?** Select all that apply.	1. Planetarium dome 2. Inflatable dome 3. 3-D theater 4. Museum exhibit 5. Classroom or library 6. Live-streams 7. Photos or videos on social media 8. Other publications (online or print) 9. Another not listed: _____

Q3b	**To the best of your knowledge, how often has this institution used OpenSpace in the past year?** Select one that fits best.	1. About every day 2. Once per week 3. Once to a few times per month 4. Every other month 5. 2-3 times a year 6. Once a year or less 7. Not in the past year
Q4	**How often do you personally engage with OpenSpace software?** Select one that fits best.	1. I have seen OpenSpace software or presentations that use it, but I have not directly used the software before. **(SKIP to Route B)** 2. About every day 3. About once per week 4. Between once to a few times per month 5. About every other month 6. About 2-3 times per year 7. Once a year or less 8. I have not used OpenSpace in the past year.
Route A *(For those who have used OpenSpace)*		
A1	**Where have you used OpenSpace?** Select all that apply.	1. In the dome where I work 2. At work, but not necessarily in the dome 3. At home on the computer 4. With other colleagues (in person) 5. With other colleagues (online) 6. Other: _____
A2	**In the past 12 months, how did you use OpenSpace?** Select the frequency that you did each activity in the past year. *[MATRIX with frequency: Never, 1-2 times, 3-4 times, more than 4 times]*	1. I worked with interns, mentees, or students. 2. I presented live to the public. 3. I presented live to colleagues or students. 4. I presented stills or videos to the public. 5. I presented stills or videos to colleagues or students. 6. I researched or visualized data. 7. Other: _____

A3	**Please rank your ability to fly in OpenSpace.**	1. I cannot fly. 2. I am learning to fly. 3. I fly ok. 4. I fly well. 5. I fly with total ease.
A4	**What are 1-3 things with using OpenSpace in your dome <u>that are working well</u>?**	1. Stunning visuals 2. Ease of usability 3. Variety of available content 4. Other: _____
A4b	**Say more about what is working well.**	*Open ended*
A5	**What are 1-3 things about using OpenSpace in your dome <u>that don't work well</u>?**	1. Updating software 2. Loading maps 3. Projector alignment 4. Variety of available content 5. Usability 6. Other: _____
A6	**Do you feel like you have enough time to do what you want to with OpenSpace?**	1. Yes (SKIP to A8) 2. No
A6b	**What would you do if you had more time with OpenSpace?**	*Open ended*
A7	**What is the single change you would like to see the most in OpenSpace?**	*Open ended* (SKIP to Demographics)
Route B *(For those who haven't heard of OpenSpace OR For those who have heard of OpenSpace but haven't used it)*		
B1	OpenSpace is … *(description, link to website).* **Does this seem like something that could be useful in the dome where you work?**	1. Yes, I could probably use it now. 2. Yes, but not now; I could maybe use it in the future. 3. No, I can't use it now or in the future. (SKIP to B4) 4. I'm not sure yet.

B2	**What questions do you have about OpenSpace that would help you to assess and understand it?**	*Open ended*
B3	**What interests you about exploring OpenSpace further?**	1. It might be better visuals than our current space visualization software. 2. It might be better than our current software because it's free. 3. It might be easier to use than our current software. 4. We currently do not have working visualization software. 5. I like the idea of connecting with an open-source community. 6. I like the ability to visualize NASA missions. 7. I like the capability to run planetarium software on other computers in my institution. 8. Other: _____ 9. I don't know what benefits it would have. I need to learn more.
B4	**Does your dome have content production or display issues you wish OpenSpace could help with?**	1. Yes 2. No [SKIP to B5]
B4a	**If yes, what sort of issues?**	*Open ended*
B5	**Which of the following barriers would there be to incorporating OpenSpace into your work, if any?** Select all that apply.	1. My current visualization software program has everything I need. 2. My dome must use our current software due to funding or contracts. 3. I, and/or my colleagues, don't have enough time to learn new software. 4. We don't have enough employees to run OpenSpace. 5. Our dome cannot run OpenSpace due to technical reasons.

		6. I don't know what is available in the software. 7. My IT department is blocking the software. 8. Other:
Demographics		
D1	**In what year were you born?**	*1. (Fill in year)* 2. Prefer not to say.
D2	**Which of the following best describes you?** Select all that apply. AMNH and NASA are trying to ensure they reach a wide variety of informal science and space-related professionals.	1. Female 2. Male 3. Non-binary or Two Spirit 4. Trans 5. Another gender not listed: ____ 6. Prefer not to say
D3	**Which of the following best describes you?** Select all that apply. AMNH and NASA are trying to ensure they reach a wide variety of informal science and space-related professionals.	1. Arab or Arab American, Middle Eastern, or North African 2. Asian or Asian American 3. Black or African American 4. Hispanic or Latino/a/x 5. Indigenous, Native, American Indian, or First Nation 6. Pacific Islander 7. White 8. Another race or ethnicity not listed: _____ 9. Prefer not to say

Wrap-up Questions		
W1	Thank you so much for answering our questions! **If you would like us to donate $5 to one of the organizations listed below, please select which one.**	1. International Dark Skies 2. Astronomical Society of the Pacific
W2	**We would love to stay in touch with you about future OpenSpace advancements if**	*Open ended*

	you're interested. What is your name? (Optional)	
W2a	**What is your email address?** (Optional)	*Open ended*
W2b	**Would you like to receive an invitation to the OpenSpace Slack channel?**	1. Yes please! 2. No thank you (SKIP to W3)
W3	**Is there anything else you'd like to say to the OpenSpace team?**	*Open-ended*

IX. Appendix - Attached Information

OpenSpace Version 0.20.0 Changelog
OpenSpace Version 0.20.1 Changelog
OpenSpace Developer Meeting Agenda
OpenSpace Funded ISI Partner Meeting Agenda

0.20.0

Compare

alexanderbock released this Jun 17 · 150 commits to master since this release

releases/v0.2... 14cf12d

You can download pre-built binaries from here. Or find more information on our homepage.

You can find a list of breaking changes against 0.19 here.

Features

- Reworked the https://docs.openspaceproject.com documentation and moved all static information from the documentation folder to the "Reference" section on that webpage
- Add a new property to control whether the global blackout factor should apply to the master rendering (#2923)
- Add a persistent file used to store user settings such as which profile or configuration file to use (#2931)
- Shifting the keybindings (closes #1055)
  - Add new action to instantly toggle all trails
  - Instead of 'H', the 'T' keybind now toggles all trails
  - Shift+T instantly toggles trails
  - Instead of 'W', the 'B' toggles the blackout of the rendering
- Improve the responsiveness of the user interface when dragging and dropping files (#3289, #3325)
- Add support for audio playback using local MP3 files (#3085)
- Add support for a new MPCDI format used by COSM/E&S using https://tools.openspaceproject.com (#3042)

- Point Cloud rendering overhaul
  - A total overhaul of the way point clouds are rendered (#2932)
  - Add ability to load labels directly from CSV/SPECK for PointClouds (#2989)
  - A more intuitive way of handling the scaling of points that works more reliable in multi-projector setups (#2994)
  - Add the ability to interpolate positions and values for points of different timesteps (#3002)
  - Add the rendering of outlines for points (round, square, or bottom) (#3044)
  - Add the ability to specify comments in CSV files
  - Add individual textures to points that are specified by columns in the data values (#3068)
  - Add settings for the use of texture compression to reduce overall memory footprint
  - Support for orientation data point cloud data (#3168)
- Partial overhaul of the star renderer (#3164)
  - Remove previously unused rendering method using point point spread functions
  - Stars are now represented by two textures that are layered on top of each other, each with their own settings to tweak the look and feel of the stars
- Add an explicit layer order to globe layers rather than relying on insertion order (#3281)
  - Added zIndex parsing for .info files (#3298)
- General improvements for trail rendering
  - Improve the performance of the trail rendering (#3287)
  - RenderableOrbitalKepler trail now shows the entire trail of an object properly (#2964)
  - Trail fading controls have been improved. Objects now have separate controls to determine the overall length of the trail and the percentage of the total that should be faded out (#1067, #2072, #2235)
  - Trajectory trails now goes through the spacecraft when using `AccurateTrailPositions` (#625)
  - `RenderableOrbitalKepler` (Asteroids and satellites) can now be rendered as both trails and points (or both at once (#1212, #1472)
- Remove support for the deprecated XML configuration file format in favor of JSON-based configuration files. A converter is available at https://tools.openspaceproject.com
- File updating
  - The HttpSynchronization now keeps track of files downloaded, speeding up resuming of partial downloads at startup (#2587)
  - The UrlSynchronization now has an option to limit download rates to, for example only download new satellite trajectories once per day (#2586)

- Show warnings and error messages on the loading screen (#2941)
- Add log rotation to the log file and the script log, keeping the last 5 by default (#2995)
- Add the ability to drag-and-drop a video file to add it as a ScreenSpaceRenderable (#2988)
- Change the navigation state format from Lua to JSON and add the current simulation time to the state. Add the ability to set the navigation state in the profile editor based this file (#3023, #3078)
- Allow transparency for movies (#2792)
- ScreenSpaceRenderables are now affected by the RenderEngine's blackout factor, hue, value, saturation, and gamma values. It is possible to ignore the blackout factor (#2868, #3293)
- Add new environment variable to control the location of the MRF cache. If it is not provided, but OPENSPACE_GLOBEBROWSING is, it is stored in a `mrf_cache` subfolder instead
- Move the local bookmarks file from `data` to the `user` folder
- Commandline
  - Remove the ability to specify a generic Lua script as a commandline argument
  - Add the ability to set selected individual commandline options instead
  - Add the ability to override the openspace.cfg file by providing an openspace.cfg.override file
- Add a new property to control how long the fading takes when jumping between screen graph nodes
- Allow the SessionRecording subsystem to write a file outside of the `user/recordings/` folder (#3150)
- Make the co-rotation of the camera dependent on the bounding sphere rather than interaction sphere (#3017)
- Move the global customization script from the `scripts` folder to the `user` folder (#3198)
- Add the ability to limit camera the camera movement to only orbit around a node's "up" axis (#2874)
- General performance improvements when starting OpenSpace (#3142)
- Add the ability to have the idle rotation to orbit around a node's "up" axis (#2916)
- Remove the ability to set alpha channel for windows
- Remove ability for external control ports (#80)
- Remove unused loading screen progress bar as it does not show an accurate estimation of times and was rarely used

- Increase the default value for linear rotation speed of the automated camera path navigator (#2584)
- Add the ability to export the focus node's model matrix in an ASCII session recording
- Show the amount of downloaded data as soon as the download is started (#2460)

Launcher

- Add a new control panel to the main window to control the contents of the new persistant storage
- Add a search and filtering to the profile assets editor (#2623)
- Add tooltip descriptions in the launcher for window configurations (#2475)
- Harmonize naming of accessing the script log in the launcher
- Automatically scroll to the bottom of the script log list by default (#3268)

UI

- Add more options for the focus menu (#167)
  - Add some initial buttons for flying
  - Add a focus button
  - Add a section with settings
  - Make the zoom-to button work for any node and provide a tooltip hint
- Add the ability to create new custom user panels by placing them in the `user` folder or providing a URL
- Add a "Quick Access" entry in the Scene menu to provide access to featured nodes (#174)
- Add new settings settings to exoplanet panel (#163, #1440, #2943)
  - Add checkboxes for habitable zone and show uncertainty of orbits
  - Add tooltip information explaining the different settings
  - Prevent errors when no systems are added
  - Add setting for 1 AU size ring
  - Add tags that can be used to set object visibility from UI
  - Add module property for hiding/showing orbiting uncertainty disc
  - Add tag for 1 AU ring and change color to something that's different from orbits
  - Add property for circle color
- Add a new button to open the GUI in an external browser (#182)
- Add settings for the jump-to functionality (#3080)

- The geoposition panel layout has been overhauled to make it more user-friendly
- Improve information in Node Meta panel to be more clear (#154)
- The "Show only enabled" option in the Scene menu should show only visible nodes (#160)
- Improve search functionality in the the Scene menu and add the ability to show hidden nodes (#3082)
- Show a timer for how long time left in camera path (#2665)
- Remove duplicated UI code and make "Browser" and "Remote" versions of the UI to be the same (#168)
- Update icons to use the react-icons package instead of online resources (#2794)
- Always show all nodes in ImGui, even if SGN has `guiHidden` property is true

Content

New Profiles

- Add a new profile for the Euclid mission (#2970)
- Add a new profile for the BepiColombo mission (#3000)

New Assets

- Add a new asset showing the Tiangong space station
- Add two more joystick controller assets
- Add a new asset to show a text marker for the moon (#2831)
- Add assets to provide with default colormaps (#2985)
- Add asset showing only the Big Dipper constellation (#3157)
- Add time reversal and sidereal actions (#3159)
- Add new asset showing the historical epicycle concept (#2518)

New Maps

- Add temporal map layer that presents the imagery from the VIIRS instrument on NOAA21
- Add new map layer showing the last 5000 years of eclipses (#3069)

Updates to existing Assets/Profiles

- Update the orientation of the ISS to be correctly along the trajectory for +/- 1 day of the current day
- Overall Layers maintenance (#2917)
  - Separate layers for the Moon and Earth
  - Provide separate assets for Utah, Sweden, and New York servers
  - Add new layers structure for Mars and Europa
  - Add layers assets for Mercury and Enceladus
  - Add more layer assets for all servers
  - Rename Venus Utah cloud combo layer asset
- Update dataset for the solarsystem small body database (asteroids and comets mostly) (#3291)
- Update the exoplanet dataset (#3301)
- Update Star position to match the star locations in the global bookmarks file (closes #3258)
- Add a mission timeline file to the JUICE mission (#2823)
- Update the Voyager kernels to reach year 2100 (#2790)
- Update faulty tags for Charon and update some other Pluto moon tags for consistency
- Global pass over all actions to make most of them not local
- Disable minor moons of Jupiter and Saturn on startup in the `default_full` profile (#3169)
- Simplify Apollo LEM Model Rotation
- Rename TileLayer to TileProvider classes (#2767)
- Remove end time from JWST model (#3135)
- Decrease the limit zoom in the Osiris-REx profile (#2473)
- Move Sun light source specification from sun.asset to transforms.asset
- Update the Voyager model file to improve the rendering speed and remove extra Blender box (#3035)
- Update to the new chlorophyll layer provided by NASA GIBS (#2959)
- Add additional tags to minor moons, trails, and labels of Jupiter and Saturn (#3272)
- Moved Spout-based layer for Earth to examples folder
- Removing all 'SSSB' elements in GUI path of the solarsystem/sssb assets and replacing the name with more descriptive names (#3322)
- Update density_volume.asset to use correct transferfunction

Content creation

- Merge `asset.localResource` and `asset.syncedResource` into a single `asset.resource` (#2906)
  - The old functions still work, but will provide a deprecation warning
- Change name of line fade in RenderableTrail from Fade to LineFade (#2857)
- Add the ability to specify a border for ScreenSpaceRenderables (#1867)
- Add the ability to specify the `BlendMode` and `Z-Index` from .info files for layers (#3311)
- Add the ability to specify local Sun position for the `RenderableGlobe` and `RenderableAtmosphere` (#1745, #2243)
- Add new renderable that can show and arrow from one node to another node (#2219)
- Add pivot property to move origin of model files
- Reorganization of SPICE file handling (#2975)
  - Move kernel loading into spice files
- Add the ability to convert TLE files to SPICE kernels (#3073)
  - Define Spice IDs inside assets
- Make the GeoJSON file extension parsing more flexible in Lua function (#2797)
- Allow reading GeoJson files with null geometry (#2811)
- Add property to control the actual bounding and interaction sphere value (#2967)
- Make the DestinationFrame in the SpiceRotation optional and use GALACTIC if it is not specified
- Remove the ability to implicitly load kernels from `SpiceTranslation` and `SpiceRotations` in favor of explicitly calling `openspace.spice.loadKernel`
- Remove "interesting times" concept as it has been superceded by the missions UI (#2991)
- Change the LuaScale to request a single table as a return value to be consistent with the other Lua transformation types
- Add a new property to the session recording to overwrite the scaling value when playing back a session recording and dynamically calculate it instead
- Add the ability to load additional exoplanets from a CSV file (#2225)

Lua

- Rename a number of functions to harmonize their naming scheme (mostly removing `get` prefix) (#2840)
- Remove the ability to have optional parameters in the beginning of Lua functions. This makes the `goToGeo` and `flyToGeo` globe first parameter a required parameter instead

(#3151)

- Rename `goToGeo -> jumpToGeo` (#3296)
- Add a function that resets the camera back to the profile start position (#2825)
- Add a function to remove all loaded assets (#2812)
- Add functions to get a list of all scene graph nodes, scene graph nodes by renderable type (#2558), and all screenspace renderables
- Add a function to return a list of scheduled scripts (#1891)
- Add a function to return a list of all loaded kernels
- Add a function to load a JSON file and return it as a Lua table
- Add functions to access configuration settings
- Add a function that reports if we are recording a session (#2559)
- Adding a function to return whether the in-game time is currently paused

API

- Add a new topic to provide information about events (#3010)
  - Add the ability to subscribe to events via the JavaScript API
- Publish an event when a scheduled script is executed (#1892)
- Publish an event when adding or removing scene graph nodes
- Publish an event when adding or removing actions

Bug Fixes

- Prevent flexing checkbox to change size (#2804)
- Remove extra background, making settings button darker than wanted
- Fix an issue that would cause actions to be triggered twice in a clustered environment (#2768)
- Provide some more information in the GEOS errors when loading a GeoJSON file fails
- Put Statue of Libery back on Liberty Island (#2787)
- Offset sample coordinate by 0.5 when estimating height values, fixing an issue with height map misalignment (#2769)
- Allow negative values for KeplerTranslation values (#2784)
- Update offline Mars map to fix 180 degree offset
- Correctly show the Apollo 17 insignia
- Prevent a crash from occurring when no shadow caster is provided or available
- Fix aspect ratio issue for RenderableVideoPlane (#2815)

- Fix issue where the in-game time is wrong when trying to start a profile with the time paused (#2826)
- Set the user position to be (0,0,0) which fixed the creation of Fisheye configurations (#2818)
- Fix fatal error when starting profile with navigation state camera setting
- Fix issue with the action to "Hide all constellation lines"
- Perform an update after creating a ScreenSpaceRenderable, causing images to be loaded immediately and provide error messages to the user (#2848)
- Transmit the GlobeName through the TileProviderByLevel, making it possible to MRF cache combined layers separately
- Don't explicitly specify data and index file names and not use the same name twice
- Fix rendering issues with debug spheres (#2849)
- Remove tile-padding to reduce stair-stepping issues in globe height layers at high resolutions (#2842)
- Fix faulty deinitialization in scene graph nodes that would cause nodes to be ignored (#2851)
- Make sure that the volume textures never gets smaller than 1x1 (#2852)
- Use correct error type in the GeoJSONComponent
- Correctly handle (0,0,0) camera vectors in the navigation subsystem
- Fix issue with non-ASCII characters when making identifiers
- Fix error with eclipse shadow cone flipping
- Use linear texture filtering on AMD until the crash can be fixed (#2843)
- Add selected Additional Scripts in the launcher by row-order, not the order in which they are selected (#2862)
- Nuke the cache folder when an inconsistent state in the cache is detected, rather than crashing (#2850)
- Fix crash when flying to NS with nonexisting anchor, and actually print error from path creation
- Resolve window config GUI edit meta problem (#2860)
- Add special handling for a number of properties in the DashboardItemPropertyValue (#2899)
- More explicit handling of zero duration paths (#2947)
- Prevent crash when using a joystick asset from a previous OpenSpace version (#2927)
- Fix a problem in which the up-direction was not being correctly computed in all cases (#2955)
- Keep track of aim from a navigation state when creating a camera path (#2981)

- Fix an issue where camera transition events would not be triggered when jumping to a scene graph node (#2949)
- Make the RenderableFOV and Missions more resilient to empty values being passed in the file
- Fix for crash when reading meta of corrupt config file (#2976)
- Fix an issue where the VideoPlayer was not correctly updated when writing out frames in SessionRecording
- Fix issue with overflowing color values for layers (closes #2880)
- Fix faulty colors when computing HSV from invalid RGB values
- Prevent point overflow when viewing the solar system position far in the future (#3021)
- Fix a rendering issue when creating a Planar Projection with incorrect FOV values
- Increase the timeout for the GDAL HTTP requests and updated url for loading gibs (#1250)
- Switch all getline reads to tolerate line endings of any operating system (#2754)
- Prevent crash when trying to load a cluster configuration when not being part of the cluster
- Correctly load triangular faces for OBJ meshes (#78)
- Don't crash when trying to remove a shader program without an OpenGL context
- Prevent mouse events from passing through mission timeline causing camera movements when interacting with other UI elements (#2893)
- Only select on keypress in the WebUI if the key was ENTER
- Prevent constant rerender of origin picker which caused performance bugs
- Fix an issue where nodes without a GUI tag would not show in the scene menu (#2174)
- Add a fix where the time display would break for times greater than 9999 (#181)
- Fix an issue where the first dashboard item would be rendered too high, making it possible to add single-item dashboards to the dome surface (#3067)
- Fix for an issue where the bounding sphere for a projection model was not calculated automatically (#2319)
- Fix the faulty computation of Sun position in atmosphere which used the Solar System Barycenter before (#3250)
- Fix an issue where out of range B-V values for stars would cause a star to get an unphysical color (#2404)
- Fix an issue that could cause a crash when adding a video plane at runtime (#3163)
- Correctly handle old ImGUI UI code when OpenSpace is compiled without GlobeBrowsing support (#3266)

- Force recompilation of the RenderableGlobe shader when moving layers which caused errors when showing solid color layers (#3295)
- Fixed a crash that could occur when accessing a layer name after it has been deleted (#3283)
- Fix a bug where a non-interpolating TimelineRotation would disappear before the first keyframe (#3310)
- Fix issue that would cause the ESRI layer to not be loaded correctly around the south pole by correctly specify its size (#2968)
- Fix so that objects are only disabled on fade 0 if the checkbox was actually clicked (#2873)
- Fix the LuaScale, LuaTranslation, and LuaRotation classes as they were broken
- Fix crash that would occur when trying to unload an asset that requires a root asset

▼ **Assets** 2

Source code (zip) Jun 17

Source code (tar.gz) Jun 17

1 1 person reacted

OpenSpace / OpenSpace Public

Code Issues 654 Pull requests 2 Discussions Actions Projects

Releases / releases/v0.20.1

0.20.1

Latest

Compare

alexanderbock released this Jul 18 · 107 commits to master since this release

releases/v0.2... c26f9db

You can download pre-built binaries from here. Or find more information on our homepage.

You can find a list of breaking changes against 0.19 here.

Features

- 2024 Digital Universe Data Update
- Add new TileProvider to select tile providers based on the date and apply to VIIRS Joint Polar Satellite System (#3350)
- Provide better error messages when failing to load an asset due to verification failures
- Add support for model vertex colors (#3346)
- Reduce the number of capture threads used by SGCT to optimize image sequence framerate
- Add server name to parallelpeer authentication, used as unique identifier on wormhole server
- Add the ability to scale the debug statistics graphs
- Move the statistics and frame info rendering from the RenderEngine into the debugging module (#1248)
- Update Ghoul to get more information on when WMI queries fail (#3330)

UI

- Add possiblity to sort SGNs in GUI based on numerical value
- Small Node Popover menu refactor

Content

New Assets

- Add an example asset to show the current in-game time in a screenspace object (#3312)
- Add new advanced example assets for the point cloud rendering

Updates to existing Assets/Profiles

- Add Down and Up keybinds to set the time to realtime and "now" respectively (#3275)
- Fix spelling mistake in Haumea model
- Fix a warning from hdf.asset due to a missing dataset parameter (#3343)
- Removed the version numbers from asset files as they were unused and inconsistent
- Remove the large data files from the URLSynchronization example files to make the file loadable
- Use the correct way to scale the Eiffel tower educational asset

Content creation

- Add the ability to specify DashboardItems for ScreenSpaceDashboards in assets.
- Make the 'Layer's specification in RenderableGlobe optional
- Improve error messages and export DashboardItem documentation
- Adds a task to generate a raw volume (used in for example RenderableTimeVaryingVolume) from a CSV file.
- The default for actions is now to have them not local (#3194)

Lua

- Add Lua function to calculate the number of seconds between dates and use it in assets (#3332)
- Add a new Lua function to create debug axes for the current focus node

Bug Fixes

- Fix a multithreaded access to SPICE that could cause a crash on startup (#3345)
- Fix a bug where the keyboard shortcuts would no longer be displayed
- Correctly consume char-based keyboard callbacks in the CEF module (#3290)
- Prevent crash when starting without any enabled audio devices (#3329)
- Fix bug with resizing the WorldWideTelescope window
- Fix an issue with the point cloud rendering texture not being rendered when the texture file path is updated during runtime
- Fix a faulty example GUI path in the point cloud example files
- Generate the framebuffer for screenspace rendering without mipmapping as it handles transparency poorly
- Fix parsing TLE files with CRLF line endings on unix (#3326)
- A non-main dashboard is now correctly displayed when adding it as a propertyowner to a ScreenSpaceDashboard
- Fix an issue where the scale for ScreenSpaceDashboards was always enforced to be 1

▼ **Assets** 2

2 2 people reacted

OpenSpace

All Hands Meeting
April 15, 2024

Join Zoom

EST / CEST	
8:00 / 1400	**Welcome**
8:10 / 1410	**Update on 0.20.0 release**
8:25 / 1425	**Work Package 1**: Domecasting / Astrocasting / Parallel Connection
8:35 / 1435	**Work Package 2**: Connections to scientific software
8:45 / 1445	Break
8:55 / 1455	**Work Package 3**: Enhanced interaction modes and presentation tools
9:20 / 1520	**Work Package 4**: Community features and user-generated content
9:45 / 1545	**Work Package 5**: Enhanced event system
9:50 / 1550	**Augmentation**: WebRTC
10:20 / 1620	**NASA content deliveries**
10:30 / 1630	**Version 1.0 discussion**
11:00 / 1700	End

OpenSpace

Annual ISI Partner Meeting
June 24-25, 2024
American Museum of Natural History

Monday, June 24
Join Zoom — Times in EDT
Room: Wet Lab, Gilder Floor 3

9:30-10:00 am	**Breakfast**
10:00-10:15 am	**I. Welcome** (15 min)* *Facilitator: Ro*
10:15-10:45 am	**II. SciAct Grant 2.0 Progress** (30 min)* *Facilitators: Ro*
10:45-11:45 am	**III. Release Updates** (1 hour)* *Facilitators: Micah & Alex* ● Recap version 0.20.0
11:45-12:15 pm	**IV. Remaining Development for 2.0** (30 min)* *Facilitators: Micah & Alex*
12:15-1:30 pm	**Lunch**
1:30-3:00 pm	**V. ISI Partner Share Outs** (1.5 hours; 25 min per partner)* ● Adler, Cal Academy, DMNS ● 15 min presentation plus ten min discussion for each partner
3:00-3:15 pm	**Break**
3:15-4:45 pm	**VI. ISI Partner Share Outs Continued** (1.5 hours; 25 min per partner)* ● HMNS, NCMNS, AMNH
4:45-5:00 pm	**VII. More User Activity** (15 min)* *Facilitators: Megan & Micah*
5:15-7:00 pm	**VIII. Dome Show** (1.5 hours) ● Partners present on dome ● Version 0.20.0 highlights
7:30 pm	**Dinner** *Bustan - 487 Amsterdam Ave*

Tuesday, June 25
Join Zoom — Times in EDT
Room: Wet Lab, Gilder Floor 3

9:30-10:00 am	**Breakfast** (30 min)
10:00-10:15 am	**Group Picture** (15 min) *Wear your OpenSpace shirt!*
10:15-11:00 am	**I. SciAct Grant 3.0** (45 min)* F.6 Science Activation draft solicitation
11:00-12:00 pm	**II. Evaluation Findings** (1 hour)* *Kate & Madeleine*
12:00-12:30 pm	**III. 2025 OpenSpace User Meeting Brainstorm** (30 min)* *Micah & Megan*
12:30-1:30 pm	**Lunch** (1 hour)
1:30-1:45 pm	I**V. Community Hub** (15 min)* *Alex & Micah*
1:45-2:30 pm	**V. Birds of a Feather Breakouts** (45 min)
2:30-3:00 pm	**VI. Wrap up discussion** (30 min)* *Ro*
3:00 pm	**Optional technical discussion / Q&A** *Alex & Micah*

*Session available on Zoom: https://amnh.zoom.us/j/95550555023
Meeting ID: 955 5055 5023
Dial-in: + 1 929 205 6099 US (New York)
+1 312 626 6799 US (Chicago)
+1 346 248 7799 US (Houston)
+1 669 900 6833 US (San Jose)