

OPENSOURCE: INTERACTIVE PUBLIC OUTREACH IN A VIRTUAL WORLD. M. E. Gemma^{1,2}, C. Roe¹, M. Acinapura¹, C. Emmart¹, D. S. Ebel^{1,2,3}, R. Kinzler¹, V. Trakinski¹, B. Abbott¹, and R. L. Smith^{4,5,6}. ¹American Museum of Natural History, New York, NY 10024, ²Department of Earth and Environmental Sciences, Columbia University, New York, NY, 10027, ³Graduate Center of CUNY, New York, NY, ⁴NC Museum of Natural Sciences, Raleigh, NC 27601, ⁵Appalachian State University, Boone, NC 28608, ⁶UNC Chapel Hill, NC 27599.

Introduction: OpenSpace [1] is an open-source interactive data visualization software designed to visualize the known universe and our ongoing efforts to investigate the cosmos. OpenSpace supports dynamic presentation of data from observations, simulations, as well as space mission planning and operations, and allows visualization at the outcrop level on extraterrestrial bodies.

The software has continued to be developed as a collaboration between software engineers and graduate students at American Museum of Natural History (AMNH), Linköping University, New York University (NYU) Tandon School of Engineering, and the University of Utah Scientific Computing and Imaging Institute.

OpenSpace can be used on a variety of platforms and operating systems, from laptops up through planetarium domes. Originally envisioned as a robust tool for immersive on-site environments, with the onset of the coronavirus pandemic (COVID-19), broad use of OpenSpace during 2020 has revealed the software's power to engage public and professional audiences through livestreamed and recorded videos by Informal Science Institution (ISI) professionals, astronomy groups, science communicators, educators, and researchers.

Invitation: OpenSpace team members are attending LPSC 2021. We are interested in presenting a demonstration of OpenSpace within or adjacent to the conference, and invite everyone to:

- 1) Ask us how you can use OpenSpace for communicating your science,
- 2) Access our tutorials, resources, and community forums to get started using OpenSpace, and
- 3) Share your feedback and ideas for the project.

Given the open-source nature of the project, anyone can develop modules for OpenSpace that visualize data, and use the software for public programming.

Public Outreach: While the COVID-19 pandemic interrupted all on-site and in-person use of OpenSpace, the software was adopted by multiple organizations and individuals for livestreamed programs and recorded videos. In 2020, 183 livestreamed programs using OpenSpace were viewed by at least 41,877 people live, and totaled 312,316 views. This is in addition to over 1 million views of recorded and previously posted videos.

These virtual programs covered a wide range of subjects, making use of new OpenSpace content and features (see below). The following are exemplars of the variety and breadth of livestream programming:

Virtual Tour of Outer Space: The content of the Morrison Planetarium at California Academy of Sciences' weekly, 30- to 40-minute program is led by a talented science communicator who takes audience chat questions and requests to guide the tour itinerary.

Science Cafés: "Space Rocks! Asteroids, Comets, and their Neighboring Planets" and "The Search for Life in the Universe" from the North Carolina Museum of Natural Sciences were after-hours programs designed to reach adult audiences but approachable for all.

Virtual Field Trip: AMNH's family- and student-friendly programs invited viewers to "hop in a virtual spaceship" for exploration of places and phenomena, from Manhattanhenge to Pluto (Fig. 1). Graduate students and other expert "chat scientists" encouraged audience engagement and questions, soliciting a total of 18,873 messages during the 15 livestreams in 2020.

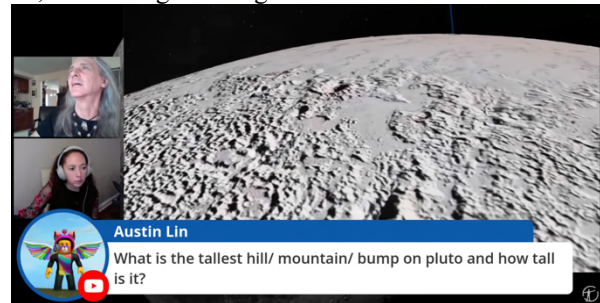


Fig. 1: Screenshot from AMNH's "Astronomy Online: Pluto" livestream, showing presenters Carter Emmart and Jackie Faherty, inset left, a viewer comment, inset bottom, and the OpenSpace visualization of Pluto.

Digital Earth: Denver Museum of Nature & Science transitioned their on-site event series to Zoom, showcasing OpenSpace's high-resolution Earth maps with virtual visits to volcanoes, craters, and deserts.

Academic and conference presentations: OpenSpace was utilized for: public presentations from Columbia University and State University of New York Orange; lectures by LaGuardia Community College and Appalachian State astrobiology professors; and presentations at IEEE Eurographics & Eurovis, International Planetarium Society, and Association of Science Technology Centers conferences, among others.

Recordings of many programs are available on the OpenSpace website [1] and YouTube channel [2].

Without the limitations of travel, programs were also able to engage more scientists, engineers, and/or researchers than would have been possible for in-person

events. In addition to experts from OpenSpace university and ISI partners [3] and other ISI users, livestreams featured professionals from:

NASA Centers: Goddard Space Flight Center’s Community Coordinated Modeling Center, Ames Research Center, Johnson Space Center, Space Radiation Analysis Group, Jet Propulsion Laboratory, Marshall Center, and Goddard Institute for Space Studies;

Scientific and research institutions: Lunar and Planetary Institute, SETI Institute, Mars Institute, and Predictive Science, Inc.;

Universities and colleges: Appalachian State University, College of Charleston, Columbia University, City College of New York, City University of New York, San Francisco State University, Southwest Minnesota State University, and University of Chicago.

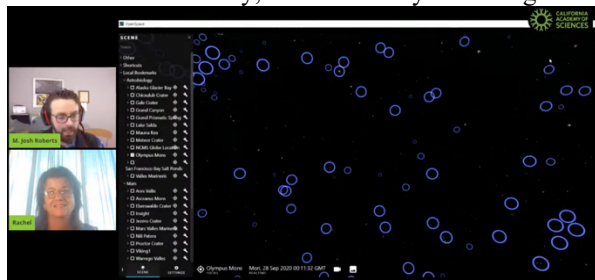


Fig. 2: Screenshot from Morrison Planetarium at California Academy of Science’s “Cosmic Conversations” livestream, with host M. Josh Roberts and presenter Rachel Smith, inset, and exoplanet markers in OpenSpace.

Education: OpenSpace has supported 159 internships to date. In 2020, the software was utilized in virtual internships at: Adler Planetarium, AMNH, Houston Museum of Natural Science, Linköping University, NASA Coordinated Community Modeling Center, NYU, North Carolina Museum of Natural Sciences, and University of Utah. These high school to graduate students focused on supporting, producing, and giving public presentations; adding new content into OpenSpace; and developing major new software features.

AMNH also used OpenSpace in two camps for 71 middle-school aged students: The in-person “Our Place in Space,” and the virtual “Coding Climate Change.”

Feature Development: In 2020, three significant software updates were published: Beta-6 (v0.15.1), Beta-7 (v0.15.2), and Beta-8 (v0.16.0). These updates not only improved performance and stability, but also made adoption easier for new users. Major features introduced in these updates include:

Presenter Profiles and Profile Editor: Select, customize, and save your favorite content and settings as a Profile through a graphical user interface (GUI). This previously required editing a text file. Additionally, planetary global map layers are now their own asset, allowing for highly customizable Profiles.

Web GUI navigation panel: The Web GUI now has a flight panel. This allows a user to show OpenSpace on one device and fly on another, useful for presenting.

Meta information: Descriptions, sources, and rights information about datasets are now available within OpenSpace through the Info button. This information can also be more easily added to new content.

Work has also begun to connect OpenSpace more seamlessly to Glue [4], an innovative software package for visualizing multiple linked datasets.

Content Development: There are 18 interactive “scenes” available with the standard download of OpenSpace, descriptions of which can be found on the installation page of the OpenSpace website. Scenes are designed to be the backdrop of a particular story that can be told with the data included in OpenSpace. In the last year, one new scene and augmented content were incorporated into OpenSpace:

Asteroids and Comets scene: The trajectories of more than 936,000 asteroids and comets from JPL Horizons Small-Body Database were added to OpenSpace.

Exoplanet systems: The over 4,000 confirmed exoplanets and host stars from the NASA Exoplanet Archive can be added to any scene using a new menu. The uncertainty of the semi-major axis is visualized by a colored, weighted band around exoplanet orbits.

Orion Nebula model: A polygonal Orion Nebula model from the Digital Universal Atlas, scaled with World Wide Telescope images, was added to all scenes.

Mission visualizations: Model and trajectory of the Mars 2020 Perseverance rover; and time range to Voyager rotations.

New content in Default scene: Fully-texture model of the International Space Station; shadow on Saturn’s rings; constellation illustrations; Venus’ atmosphere; and trails for C/2019 Q4 “Borisov” interstellar object and C/2019 Y4 (ATLAS) comet.

Discussion: OpenSpace’s visualization of scientifically important data and missions enabled individuals and organizations to virtually connect with thousands of people during the pandemic. Using OpenSpace, presenters were able and continue to visually explore and explain how we engage in discovery across the Solar System and beyond.

References:

- [1] <http://openspaceproject.com/>
- [2] www.youtube.com/c/openspacesoftware
- [3] <https://www.openspaceproject.com/partners>
- [4] <https://glueviz.org/>

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