

OPENSOURCE: INTERACTIVE VISUALIZATION OF SPACE SCIENCE

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Introduction: OpenSpace [1] is an open-source interactive data visualization software designed to visualize the known universe and humanity's ongoing efforts to investigate the cosmos. OpenSpace supports dynamic presentation of data from observations and simulations, as well as space mission planning and operations, and allows visualization at the outcrop level on extraterrestrial bodies [2].

This software has continued to be developed as a collaboration between software engineers and graduate students at the American Museum of Natural History (AMNH), Linköping University (Sweden), 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 to planetarium domes. During the coronavirus Covid-19 pandemic, broad virtual use of OpenSpace revealed the software's power to engage public, professional, and academic audiences through livestreamed and recorded videos by Informal Science Institution (ISI) professionals, astronomy groups, science communicators, educators, and researchers. As we return to on-site environments OpenSpace remains a robust, dynamic tool for presenting a broad range of immersive experiences.

Invitation: OpenSpace team members (* in author list) are attending MetSoc 2022 in Glasgow. We are interested in presenting a demonstration of OpenSpace within or adjacent to the conference and we 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 everyone can use the software [1] freely for public programming and teaching.

Public Outreach: From March 2021 - March 2022 OpenSpace was used to present 130 virtual/livestream programs with 11,964 live views and 21 in-person programs with 47,859 live views. In addition to experts from OpenSpace university and ISI Partners [3] and other users, livestreams featured professionals from NASA Centers and scientific institutions. Recordings of many programs can be found on the OpenSpace website [1] and YouTube channel [4]. The stunning visuals and richness and depth of the rendered data sets within OpenSpace allow for continuous fly-through-the-Universe and planetary globe-browsing experiences, further enabling its use in a range of other outlets, such as exhibits and visual storytelling spaces from museums to classrooms to the bed of an EV pickup truck.

Education: OpenSpace has been used in undergraduate and graduate courses in astronomy and astrobiology and has supported 175 internships to date. In the last year, the software was utilized in virtual internships hosted by Adler Planetarium, AMNH, Houston Museum of Natural Science, Linköping University, NASA Coordinated Community Modeling Center, NYU, North Carolina Museum of Natural Sciences, and the University of Utah.

What's new: In 2021-22, significant software updates were published, most recently Beta-11 (v 0.18.0). These updates not only improved performance and stability, but also made adoption easier for new users with the addition of extensive new documentation. OpenSpace has recently been refined to be more useful for researchers by seamlessly streaming data from software packages popular among astronomers with the open Python library called Glue [5]. Jupyter notebooks also enable loading planetary science archives from NASA TREKs and USGS. OpenSpace has also embedded the World-Wide Telescope software managed by the American Astronomical Society [6]. These innovations allow visualization of multiple linked datasets like ESA's Gaia data and NOAA's Science-on-a-Sphere [7].

There are currently ~20 interactive scenes available in OpenSpace and all of these are available in the latest release on the OpenSpace installation page [1]. Dynamic renderings of coronal mass ejections (CMEs) have been added most recently. Datasets enabling high-resolution Mars, Moon and Mercury globe-browsing are freely available.

References: [1] <http://openspaceproject.com/> [2] Gemma et al. (2021) *LPS XXXIII*, Abstract #2206. [3] <https://www.openspaceproject.com/partners> [4] www.youtube.com/c/openspaceproject [5] <https://glueviz.org/> [6] <https://worldwidetelescope.github.io/editions/2022/> [7] <https://sos.noaa.gov/catalog/datasets/>

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