

**NORTHERN ARIZONA PLANETARY SCIENCE ALLIANCE (NAPSA): YEAR 4 PROGRESS AND INITIATIVES.** J. J. Hagerty<sup>1</sup>, N. Barlow<sup>2</sup>, W. Grundy<sup>3</sup>, J. Heynssens<sup>4</sup>, R. Porter<sup>5</sup>, and T. N. Titus<sup>1</sup>, <sup>1</sup>USGS, Astrogeology Science Center, Flagstaff, AZ; <sup>2</sup>Department of Physics and Astronomy, Northern Arizona University, Flagstaff, AZ; <sup>3</sup>Lowell Observatory, Flagstaff, AZ; <sup>4</sup>Northern Arizona University, Electrical Engineering and Computer Science Department, Flagstaff, AZ; <sup>5</sup>Northern Arizona University, School of Earth Science and Environmental Sustainability, Flagstaff, AZ; email: jhagerty@usgs.gov.

**Introduction:** Research institutions in Northern Arizona, and Flagstaff in particular, have a long history of conducting high-level planetary science and astronomical research. Scientists and educators at the Lowell Observatory, Northern Arizona University (NAU), the US Geological Survey (USGS), and the US Naval Observatory, have all made key contributions to understanding the origin and evolution of the Solar System; however, collaborations among these institutions have been rare even though their experience and capabilities are complementary. Recognizing the potential benefit of a formalized framework for promoting research and education collaboration, in 2014 representatives from each of these institutions established the Northern Arizona Planetary Science Alliance (NAPSA), which has been reported on at LPSC [1,2,3]. This alliance consists of the following specific entities: NAU (Department of Physics and Astronomy, School of Earth Science and Environmental Sustainability, Department of Electrical Engineering and Computer Science, Department of Mechanical Engineering, Center for Science Teaching and Learning, and Department of Mathematics and Statistics), Lowell Observatory, USGS (Astrogeology Science Center, Western Geographic Science Center, Arizona Water Science Center, and Geology, Minerals, Energy, and Geophysics Science Center, and the SW Biological Science Center), and the US Naval Observatory.

One of the main objectives of this initiative is to provide a singular portal for members of the planetary science community, the regional school systems, and the general public to access information and resources associated with the cutting edge planetary research being conducted in Northern Arizona. As such, NAPSA has recently created a public webpage (<https://napsaconsortium.wordpress.com/>) for posting updates on NAPSA activities and initiatives. We have also developed an email list serve for updating interested parties on NAPSA efforts. Please contact the lead author if you wish to be added to the list serve.

**Rationale and Goals:** Northern Arizona has many unique characteristics that have created a nexus of planetary science research. From the abundance of terrestrial analog sites (e.g., Meteor Crater, the Grand Canyon, the San Francisco Volcanic Field, the Colorado Plateau, and the Verde Valley) to the designation of Flagstaff as the first “International Dark Sky City” ideal for telescopic

observations, to Flagstaff being named America’s first STEM community, it is clear that Northern Arizona has much to offer the planetary science community. However, the NAPSA initiative seeks to further increase the reach and impact of Northern Arizona’s planetary research efforts by combining experience, knowledge, and facilities to create a one-stop research and educational resource for anyone interested in planetary science. The establishment of a new Ph.D. program in Astronomy and Planetary Science through NAU’s Department of Physics and Astronomy will only further planetary science opportunities in Northern Arizona.

*Workshops and Seminars:* One of the major objectives of NAPSA is to increase communication between each institution via workshops and seminars. A kickoff workshop was held in May 2014 that was focused on educating scientists, staff, and students about the research being conducted, and the resources that are available at each institution. The first half of the workshop was focused on identifying road blocks that hamper collaboration and the second half of the workshop was focused on breakout discussion sessions addressing student training, research collaborations, and community outreach. A follow-up poster session was held in September 2014 at the USGS that allowed individual scientists to present research projects that could benefit from collaborations with students at NAU, as well as researchers at other institutions.

In February 2015, NAPSA hosted a workshop on the mapping of small and irregular bodies in the Solar System. The morning session was dedicated to defining the current state-of-the-art, major issues that need to be addressed, and tools and methods useful to the investigation of small bodies. The afternoon discussion session focused on mission ideas, student involvement, and opportunities for collaboration. For the first time, NAPSA began to work with entities beyond Northern Arizona, including Arizona State University and the Johns Hopkins University Applied Physics Laboratory. As a result of these efforts, NAPSA representatives began working in January 2016 with the USGS on an effort to provide an initial assessment of the mineral resources within asteroids [4,5].

In March 2016, NAPSA held a workshop on “Exoplanets and Habitability: Connecting the Very Large to the Very Small.” The focus of this half day workshop

was to discuss research in all areas related to exoplanets and the potential habitability of planetary surfaces beyond the Earth. Invited presentations by Dr. Jill Tarter and Dr. Penny Boston highlighted the agenda, which also included presenters from all NAPSAs institutions.

In February 2017, NAPSAs hosted a workshop focusing on “Volatiles Across the Solar System” with invited presentations from Dr. Charles Shearer and Dr. Zach Sharp from the University of New Mexico. The goal of the workshop was to discuss the inventory and origin volatile species as a function of distance from the Sun, with the possibility of finding new avenues of collaboration across institutions.

In 2015, 2016, and 2017 NAPSAs hosted poster sessions on the NAU campus (sponsored by the Arizona Space Grant Consortium). These poster sessions were designed to engage a broader range of students and to involve more scientists and staff. The poster sessions were covered by local media and gained the attention of local, regional, and state government representatives.

**Institutional Updates:** In 2017 NAPSAs added a new member to its list of participating institutions (i.e., *Earth Vision Science and Technology* (EVST), LLC). EVST is a Flagstaff-based, early phase startup that develops advanced, multispectral imaging systems for quantitative, near-surface environmental monitoring and analysis. EVST provides quality remote sensing systems, research, and services supporting the geospatial information and monitoring needs of Earth science.

*NAU Department of Physics and Astronomy* instituted a new Ph.D. program in Astronomy and Planetary Science in Fall 2016. The program has enrolled eight students in the first two years and applications are being reviewed for a third incoming Ph.D. class who will start in Fall 2018. Research mentors for these students are affiliated with the department, the USGS Astrogeology Science Center, and Lowell Observatory. The new Ph.D. program also led to the hiring of six new planetary science faculty members in the past two years. This brings the number of planetary science faculty in the department to 10 and covers the following fields of research: planetary surface processes, Mars spacecraft investigations, terrestrial analog studies, remote sensing, debris disks and planetary formation, exoplanet atmospheric and interior modeling, observational (telescopic) planetary science, and experimental laboratory studies of astrophysical and planetary materials. This range of topics provides a large number of funded research opportunities for both Ph.D. and undergraduate students.

*Lowell Observatory* continues to have numerous infrastructure projects ranging from restoration of historic structures, like the telescope and dome used to discover Pluto in 1930, to cutting edge modern scientific facilities, such as a major upgrade in progress at the Navy

Precision Optical Interferometer at Anderson Mesa and new instruments for Lowell's 4 meter Discovery Channel Telescope at Happy Jack, AZ. Lowell is also a major Flagstaff tourist attraction. In 2017, Lowell hosted large public events for the August solar eclipse, both in Flagstaff and along the path of totality in Madras, OR. To help accommodate an ever-growing numbers of visitors (>100,000), Lowell unveiled plans for the Giovale Open Deck Observatory, a new public observing plaza to be built on Lowell's main campus in Flagstaff. Lowell scientists are active in research from near-Earth asteroids to the Kuiper belt, and from nearby exoplanets, stars, and star formation, through galaxies and galaxy clusters.

*NAU School of Earth Science and Environmental Sustainability* continued to grow in disciplines related to planetary sciences. The school has recently made hires in geomorphology and ecology and is currently hiring an environmental geochemist. Further, the school has recently acquired a multicollector ICP-MS that is available to NAPSAs for geochemical analyses.

*NAU School of Informatics, Computing, and Cyber Systems* established a Ph.D. program and now has two dozen cross-disciplinary research professors in EE, CS, bioinformatics, geoinformatics, health informatics, astronomical informatics.

*USGS Astrogeology Science Center (ASC)* continues to be involved in numerous active missions primarily through software development and generation of spatial data products. ASC hired a postdoc and two new research scientists. ASC staff led a joint effort with NAU and Lowell Observatory to publish an Open File Report [5] on the assessment of mineral resources in asteroids. Lastly, ASC is implementing a cooperative agreement with the NAU College of Engineering, Forestry, and Natural Sciences to facilitate collaborative efforts between the two institutions.

**Future Efforts:** In February 2018 NAPSAs will host another community workshop. The focus of this workshop is to discuss relevant research in all areas related to *Hardware and software for facilitating Earth and Space Sciences*. This workshop is an opportunity to gain an understanding of current research efforts and resources within northern Arizona and to look for new collaboration opportunities. NAPSAs will also hold its annual poster session in the fall of 2018 at NAU that will focus on student education and employment opportunities in the planetary sciences.

**References:** [1] Hagerty, J.J., et al. (2015) LPSC 46, abstract #2397; [2] Hagerty, J.J., et al. (2016) LPSC 47, abstract #2209; [3] Hagerty, J.J., et al. (2017) LPSC 48, abstract #1994; [4] Keszthelyi, L. et al. (2016) LPSC 47; [5] Keszthelyi, L. et al. (2017) USGS OFR 2017-1041.