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Juno Citizen Science and Outreach

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Abstract

The Juno mission [1] has a number of aspects that involve citizen scientists and the public. There are three elements to Juno's citizen science and outreach; (1) amateur observations of Jupiter, (2) JunoCam, and (3) the Goldstone Apple Valley Radio Telescope. In keeping with the outreach goals for Juno, we opened up our operations via our website (missionjuno.swri.edu) so that the world can see how planetary science on a spacecraft is carried out. The program has been successful at engaging citizen scientists at all levels as well as sharing the excitement of space exploration with students, teachers and artists.

1. Amateur observations of Jupiter

A world-wide Jupiter-observing campaign to coordinate observations at all wavelengths from ground- and space-based assets was developed to encourage and coordinate observations from assets around the world to combine with Juno data in maximizing our understanding of Jupiter, extending and enhancing results from the spacecraft instruments themselves. This campaign involves not only professional astronomers but also a network of non-professional observers using small telescopes. The value of these observations is that they provide a far more frequent cadence, that is impossible to match with professional observatories, allowing us to alert Juno scientists and all Juno-supporting astronomers to the evolution of features in Jupiter's visible cloud deck. These include sudden-onset phenomena, such as upwelling outbreaks and impacts. Changes to the Equatorial Zone are the current center of attention.

2. JunoCam

The Juno spacecraft payload includes a camera specifically to serve the public: Junocam [2]. Designed and developed in conjunction with Malin Space Science System (MSSS), the camera is a wide-angle camera optimized to capture the unique polar perspective of Jupiter offered by Juno's polar orbit. Junocam's four-color images include the best spatial resolution ever acquired of Jupiter's cloudtops. The Juno team recognized the importance of public outreach and involvement and designed the instrument, operations and data analysis to involve the public, both professional and amateurs.

The Junocam concept for operations relies on public involvement at three stages: advance planning, image selection, and image processing. With a very small professional operations team, and together with the professional community involved in active observations of Jupiter, we rely on the public to fill in key pieces of Junocam operation. The public is an essential part of the Juno virtual team.

Amateur astronomers supply ground-based images for use in planning, as well being given the opportunity to weigh in on which images to acquire. At each perijove pass we provide insight into the scientific planning process and the factors that influence scientific decisions regarding the atmospheric features to be imaged.

Initial image processing is carried out at MSSS to construct the most basic image products. There are three types of products: (1) Experiment Data Records (EDRs) in de- compressed image framelet order, 8 bits/pixel, as received from the spacecraft; (2) monochrome Reduced Data Records (RDRs) in decompanded flat-fielded form, framelet order, 16

bits/pixel; and (3) map-projected images. The data is then made available via the web. Usually the images are published for public involvement within days of their receipt on the ground.

For additional products, we rely on the image data processing amateur community (see Figure 1). While the most basic processing is done by image processing professionals, often the next step, removing the phase function, is done by one of our citizen scientists (Gerald Eichstädt) and others use his products for the starting point to their own contributions. We encourage creativity for higher order products. Areas of effort include feature tracking, visualizations using other Juno instrument data and/or ground-based observations, methane mapping, and false color. The amateur community has responded with many beautiful and creative products. A sample of these are highlighted on the missionjuno website and the NASA Juno website: www.nasa.gov/mission_pages/juno/ multimedia/ with a more complete collection posted on missionjuno.swri.edu/junocam/processing.

As the images are processed and analyzed, links are made between science planning and outcomes. Initial reports are posted by another citizen scientist, John Rogers, on the British Astronomical Society Jupiter division website, and in the JunoCam Think Tank webpage on missionjuno.

3. Goldstone Apple Valley Radio Telescope

The Goldstone Apple Valley Radio Telescope (GAVRT) project is a partnership between NASA, the Lewis Center for Educational Research, and JPL, in which young (typically 10-16 years old) students use a 34-meter radio telescope to learn science by doing radio astronomy. One of the GAVRT science campaigns consists of monitoring emission from Jupiter at 2.3 GHz. GAVRT students collect the data, and collaborate with members of the Juno science team to analyze it. These data help to provide context for measurements by the Juno microwave radiometer (MWR), and have been used as one of many data sets that contribute to modeling the Jovian radiation belts. Further description of the GAVRT project may be found at http://gavrt.lewiscenter.org.

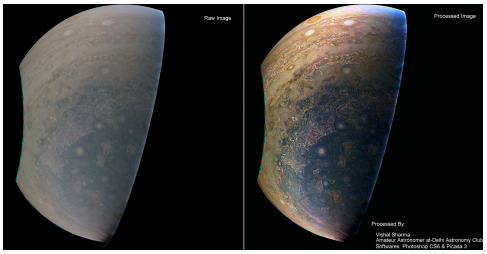

Figure 1: This is an example of the processing carried out by citizen scientists. The image on the left is the level of processing posted on missionjuno for the public to access and process.

4. Summary and Conclusions

Many aspects of this experiment in outreach have exceeded our expectations. To cite a specific example: the amateur astronomy community has helped the project decide on the best perijove passes to fly over the Great Red Spot after an interaction with the South Tropical Disturbance changed its drift rate.

Acknowledgements

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References.

[1] S. J. Bolton et al., The Juno Mission. Space Sci. Rev. 213:1, 2017.

[2] C. J. Hansen et al., JunoCam: Juno's outreach camera, Space Sci. Rev. 213:475, 2017.