

THE IO GIS DATABASE, V. 1.0: A PROTO- IO PLANETARY SPATIAL DATA INFRASTRUCTURE D.A. Williams¹, D.M. Nelson¹, and M.P. Milazzo², ¹School of Earth and Space Exploration, Arizona State University, Tempe, AZ 85287-1404 (David.Williams@asu.edu); ²Other Orb, LLC, Flagstaff, AZ (moses@otherorb.net).

Introduction: We collected a set of published, higher-order data products of Jupiter's volcanic moon Io, and assembled them in a downloadable ArcGIS™ database we are calling the Io GIS Database, version 1.0. The purpose of this Database is to collect image, topographic, geologic, and thermal emission data of Io in one geospatially registered location, to form the basis of an Io planetary spatial data infrastructure (PSDI). The goals of an Io PSDI are: 1) to make higher-order data products more accessible and usable to the broader planetary science community, particularly to new scientists that were not associated with the projects that obtained the data; 2) to enable new scientific studies with the data; and 3) to create a tool to support observation planning for future Io-focused planetary missions. In this presentation we describe the motivation behind our project, discuss the datasets acquired for this first version of the Database, and demonstrate how they can be used. We conclude with discussion of how our Database relates to other PSDIs and our plans for future updates.

Motivation: Over the last decade there has been great interest within NASA's Planetary Science Division regarding the long-term accessibility and usability of planetary data, particularly geospatial image data of planetary surfaces, and particularly the higher-order data products (e.g., regional to global image mosaics, digital terrain models (DTMs), geologic maps, etc.) derived from NASA's robotic planetary missions. NASA's desire to maximize its investment in its planetary missions and their accumulated data is motivated by the desire to enable future generations of planetary scientists to utilize the data for research projects, long after the creators of those data are gone. Likewise, NASA wants to ensure that data from past missions are usable in tools that will support planning of future missions. This is particularly desirable for geologically active worlds, such as Jupiter's volcanic moon Io, where multiple, ongoing volcanic eruptions produce thermal anomalies related to its interior processes, and where active eruptions emplace effusive and explosive volcanic materials and gases that regularly modify its surface at timescales of weeks to months [1,2].

Data & Methods: Our concept was to collect many of the accessible and usable, higher-order image-based data products of Io that have been peer-reviewed and published over the last two decades, and assemble them in a geospatially controlled and registered format to enable future work. The primary software we chose to

use is ArcGIS™, but the data are also available through ASU's JMARS software. The image basemaps on which the Williams et al. [3] global geologic map of Io was produced are available in ArcGIS™. These include a set of four combined *Galileo-Voyager* global mosaics (Becker and Geissler, 2005 [4]), in which mosaicked images were geodetically-controlled using a triaxial ellipsoid shape model and best available *Galileo* control point network [5]. Reported horizontal accuracy is nominally 1 pixel, translating to 1 kilometer in low latitude regions with good coverage. Thus, the USGS *Galileo-Voyager* Global Mosaics serve as the *foundational data products* of our Database, and are the best available prepared and controlled data set on which to build an Io database. **Table 1** lists the published Io data sets we chose to include in this first version of the Database.

Results: Data are presented using a Simple Cylindrical projection centered on the antiojovian point (0°, 180°W), as the *Galileo* mission obtained its best imaging over the antiojovian hemisphere. We included the latest named surface features from the USGS Planetary Nomenclature website, as well as a graticule displaying a 30° latitude-longitude grid. Having Io data from the 1970s, 1990s, 2000s, and 2010s in this Database enable comparisons and show the evolution in interpretation of Io's geologic features, particularly between the *Voyager* and *Galileo* eras. Importantly, the thermal hot spot datasets include attribute tables, which contain details on recorded thermal activity at every location on Io, covering a time period between 1996-2018. By checking the power, area, and temperature variations at hot spots of interest, it is possible to investigate the waxing and waning of volcanic activity over this twenty year time period.

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References: [1] Lopes and Williams, 2005. *Rep. Prog. Phys.*, 68, 303-340; [2] Lopes and Spencer, 2007; [3] Williams et al., 2011. USGS SIM 3168; [4] Becker & Geissler, 2005. *LPSC XXXVI*, Abstract #1862; [5] Archinal, et al., 2001. *LPSC XXXII*, Abstract #1746.

Table 1. Directory structure and datasets listing for the ASU Io GIS database, version 1.0. Downloadable Zipped GIS file: https://rpif.asu.edu/downloads/PDART_Io_DB_GIS_data.zip

Item Name	Description	Reference
<i>Surface Heat Flux Models</i>	Extracted from figure in journal paper.	Hamilton et al. (2013): https://doi.org/10.1016/j.epsl.2012.10.032
<i>AO Telescopic Observations</i>	2013-2018	de Kleer et al. (2019): https://doi.org/10.3847/1538-3881/ab2380
	2001-2016	Cantrall et al. (2018): https://doi.org/10.1016/j.icarus.2018.04.007
	2010	de Pater et al. (2014): https://doi.org/10.1016/j.icarus.2014.06.019
	2001	Marchis et al. (2005): https://doi.org/10.1016/j.icarus.2004.12.014
<i>Additional Hot Spot Data</i>	<i>Galileo</i> NIMS NITED Database, Part I	Davies et al. (2015): https://doi.org/10.1016/j.icarus.2015.08.003
	Hot spot locations, 1979-2007	Appendix A.2, Lopes and Spencer (2007), <i>Io After Galileo</i> .
<i>Regional Geologic Maps</i>	Chaac-Camaxtli map	Williams et al. (2002): https://doi.org/10.1029/2001JE001821
	Culann-Tohil map	Williams et al. (2004): https://doi.org/10.1016/j.icarus.2003.08.024
	Zamama-Thor map	Williams et al. (2005): https://doi.org/10.1016/j.icarus.2005.03.005
	Amirani-Gish Bar map	Williams et al. (2007): https://doi.org/10.1016/j.icarus.2006.08.023
	Zal region map	Bunte et al. (2008): https://doi.org/10.1016/j.icarus.2008.04.013
	Prometheus map	Leone et al. (2009): https://doi.org/10.1016/j.jvolgeores.2009.07.019
	Hi'iaka-Shamshu maps	Bunte et al. (2010): https://doi.org/10.1016/j.icarus.2009.12.006
<i>Global geologic map</i>	USGS I-2209 <i>Voyager</i> -based, 1:15M	Crown et al. (1992), USGS map: https://pubs.er.usgs.gov/publication/i2209
<i>Global geologic map</i>	USGS SIM 3168 <i>Galileo-Voyager</i> 1:15M	Williams et al. (2011), USGS map: http://pubs.usgs.gov/sim/3168/
<i>Mission Image Data</i>	<i>New Horizons</i> 2007 LORRI mosaic	Spencer et al. (2007), Science: https://doi.org/10.1126/science.1147621
	LEISA hotspot images and data	Tsang et al. (2014), JGR-Planets: https://doi.org/10.1002/2014JE004670
	<i>Galileo</i> SSI Digital Elevation Model	White et al. (2014), JGR-Planets: https://doi.org/10.1002/2013JE004591
<i>Galileo</i> SSI Orbit I25 observations	I25ISEMAKNG02, I25ISGIANTS01, I25ISCUANNO1, I25ISSTERM 01	Keszthelyi et al. (2001), JGR-Planets: https://doi.org/10.1029/2000JE001383
<i>Galileo</i> SSI Orbit I27 observations	I27ISTOHL 01, I27ISCAMAXT01, I27ISAMRAN01, I27ISTVASHT01, I27ISZALTRM01, I27ISSHMSHU01, I27ISSOPOLE01	Keszthelyi et al. (2001), JGR-Planets: https://doi.org/10.1029/2000JE001383
SSI Orbit I32 observations	I32ISLOKI 01, I32ISTVASHT01, I32GSHBAR01, I32ISTERMIN01, I32ISTERMIN02	Turtle et al. (2004), Icarus: https://doi.org/10.1016/j.icarus.2003.10.014
<i>USGS Galileo-Voyager Global Mosaics</i>	a) SSI only B&W, b) SSI only color, c) SSI-VOY B&W, d) Merged SSI-VOY B&W and SSI color	USGS Astropedia: https://astrogeology.usgs.gov/maps/io-voyager-galileo-global-mosaics . See also: Becker and Geissler (2005), 36 th LPSC : https://www.lpi.usra.edu/meetings/lpsc2005/pdf/1862.pdf ;
Ancillary data maps	Maps of Emission, Incidence, & Phase angles, & Spatial resolution for c) above	USGS Astropedia: https://astrogeology.usgs.gov/maps/io-voyager-galileo-global-mosaics

NOTES: (1) *Galileo* SSI I24 observations were damaged by radiation exposure to the camera electronics, and were only partially recoverable. There were insufficient resources to include them in this project. (2) Io mosaics better than 200 m/px would require too much time to tie to this database, so they are not included in this first version of the Database.