LUNASERV 3 DEVELOPMENT AND USAGE OVER THE PAST YEAR. N. M. Estes, C. D. Hanger, A. A. Licht, K. S. Bowley, S. Koeber, E. Bowman-Cisneros, School of Earth and Space Exploration, Arizona State University, Tempe, AZ 85287, nme@ser.asu.edu

Introduction: The Lunar Reconnaissance Orbiter Camera (LROC) Science Operations Center (SOC) created Lunaserv as an open source Web Map Service (WMS) [1] to efficiently render LROC images and other lunar data in the IAU2000 spatial reference systems (SRS) [2]. Lunaserv also supports other planetary bodies and their corresponding SRS sets. Support for Mercury, Venus, Earth, the Moon, Mars, Io, Ganymede, Europa, Callisto, Rhea, Tethys, Iapetus, Dione, and Enceladus is included [3], and additional bodies or projections can be added at run-time with simple YAML [4] configuration files.

Recent Developments: In the upgrade from Lunaserv 2 [1] to Lunaserv 3 the front-end was completely rewritten leading to several key improvements. The primary motivation for the rewrite was to simplify installation and maintenance. Previously, the front-end used the Ruby on Rails framework [5]; with Lunaserv 3, the smaller and faster Rack [6] framework is used directly, and the Ruby on Rails framework is no longer required for installation. This switch simplifies dependencies and also removes the necessity of installing a database. Additionally, Lunaserv 3 is fully WMS compatible. While Lunaserv 3 is not a certified WMS implementation by the Open Geospatial Consortium (OGC), Lunaserv 3 does pass all of the CITE tests published by the OGC for WMS 1.1 [7]. Finally, Lunaserv 3 introduces configurable database and authentication support. The database configuration supports PostgreSQL at install, but new database modules are also configurable in Lunaserv 3. Authentication can be done against multiple sources. Both simple username/password and LDAP authentication are available at install, and other authentication modules can be added.

In addition to these front-end changes, Lunaserv 3 includes improvements to the rendering engine as well. The illumination layer underwent the most substantial change, as it now supports the Lommel-Seeliger photometric function as an alternative to the basic Lambertian model (Figs. 1, 2) [8]. This change laid the groundwork to easily support additional photometric functions to the illumination layer in future releases. In the rendering engine, the stamp and raster layers were merged and the new raster layer supports GeoTIFF headers in pyramidal TIFF source data. The shapefile layer in Lunaserv 3 introduces the ability to draw labels in addition to shapes, and the shapefile layer is also now queryable.

The LROC SOC also contributed a modification to the QGIS project that allows IAU2000 projections to be requested via WMS [10]. Once released, this

Figure 1: Synthetic illumination of a global LROC Wide Angle Camera (WAC) reflectance map using a Lambertian photometric function to simulate real lighting on 17 December 2013 [9].

Figure 2: Synthetic illumination applied to the WAC reflectance map from a Lommel-Seeliger photometric function resulting in more realistic lighting using the same time and viewing angle as Figure 1 [9].

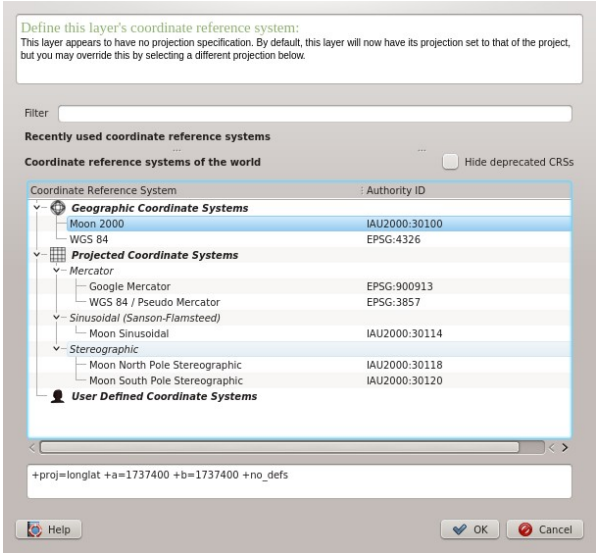

Figure 3: QGIS showing the available projections from Lunaserv WMS for the WAC Global Basemap.

modification will allow the use of planetary data in a native SRS in QGIS using Lunaserv or other WMS servers that add support for the IAU2000 projections (Fig. 3).

LROC SOC Usage: The LROC SOC operations staff employs Lunaserv for LROC observation planning with a modified version of JMARS [11] known as JMoon. JMoon allows for custom WMS parameters to be passed through to Lunaserv for any layer that supports optional parameters. This upgrade allows custom coloring, customized illumination maps, and other options not previously available in JMARS. The LROC SOC operations staff also uses Lunaserv in other tasks such as generating synthetic illumination views for oblique target planning. LROC researchers use Lunaserv for feature digitization efforts, coverage analysis, context maps, and permanently shadowed region studies. LROC SOC staff also runs Lunaserv via scripts to generate series of images that are combined to generate movies for presentations, or to visualize time series data. For digitizing efforts in particular, where tasks can consume many days of work, WMS enables researchers to continue this work from any location without first having to transmit large datasets to laptops or remote workstations.

Usage by Other Groups: From the Lunaserv release in March 2013 through December 2013, over 74,000 hits to the Lunaserv website and ~850 downloads of the Lunaserv software occurred. In the same time period, the public Lunaserv WMS server rendered over 2.1 million map requests (Fig. 4).

Primarily, the public Lunaserv server supports the LROC PDS interface allowing browsing and retrieval of LROC data by the public or outside research groups; however, based on traffic logs, the LROC SOC noted that other projects utilize the public Lunaserv server. For example, the 2013 Space Apps Challenge contributed ~10% of the traffic that the public Lunaserv server saw in April 2013. The Regional Planetary Information Facility (RPIF) at Arizona State University (ASU) uses map data from a variety of sources, including the public Lunaserv server, and combines the map data in ArcGIS for various mapping and measurement projects [12].

Future Work: As the LROC SOC continues to use Lunaserv for operations, research, and public outreach, Lunaserv will be updated with new features and capabilities as needed. Changes identified for future work include merging the raster and numeric layers to simplify and expand support for varying bit depths, Web Feature Service (WFS) support, and WMS 1.3 support.

References: [1] Estes, N.M.; et. al.; Lunaserv Web Map Service: History, Implementation Details, Development, and Uses, http://adsabs.harvard.edu/abs/2013LPICo1719.2609E. [2] Hare, T. et. al., (2006), LPSC XXXVII, abs. 1931. [3] http://lunaserv.lroc.asu.edu/. [4] YAML http://www.yaml.org/ [5] Ruby on Rails http://rubyonrails.org/ [6] Rack, a modular Ruby webserver interface https://github.com/rack/rack [7] OGC WMS Standards, http://www.opengeospatial.org/standards/wms. [8] Hanger, C. D.; et. al.; DEM-based Illumination Simulation in a Web Map Service using Lunaserv;http://lunarscience.nasa.gov/wp-content/uploads/LSF13P/Hanger_nlsf2013.pdf. [9] Boyd, A.K., et. al., LROC WAC 100 Meter Scale Photometrically Normalized Map of the Moon, P13B-1744. presented at 2013 Fall Meeting, AGU, San Francisco, Calif., 9-13 Dec [10] QGIS IAU2000 SRS Change, https://github.com/qgis/QGIS/pull/982. [11] Christensen, P.R., et. al., *JMARS – A Planetary GIS*, http://adsabs.harvard.edu/abs/2009AGUFMIN22A..06C. [12] Nelson, D. (2013 December 20); Email Interview.

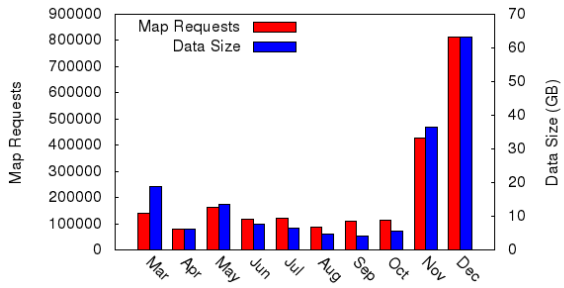

Figure 4: Public Lunaserv Web Stats