Lunaserv WMS – A Planetary GIS Server N. M. Estes, C. D. Hanger, A. Ramaswamy, E. Bowman-Cisneros, M. S. Robinson, School of Earth and Space Exploration, Arizona State University, nme@ser.asu.edu

Introduction: The Lunar Reconnaissance Orbiter Camera (LROC) Science Operations Center (SOC) operates the LROC camera, processes LROC observations, generates mosaics, maintains the LROC Planetary Data System (PDS) data node, and performs a wide variety of work using LROC observations. In support of these activities, the LROC SOC needed a way to get map data into JMARS [1], web sites, Geographic Information System (GIS) software, and generate and combine map data for other uses as well. To solve these needs, the LROC SOC first looked at existing Web Map Service (WMS) software packages. The existing WMS software at the time had various limitations including issues with global map data, no support of non-Earth Spatial Reference Systems (SRS), and performance issues with millions of observations, so the LROC SOC started development of Lunaserv in 2009 to create a WMS compatible server software supporting IAU2000 planetary SRS [2], and capable of serving the large amount of LROC data.

The first version of Lunaserv supported only the orthographic projection, and only in the Moon's coordinate system. Subsequent development enabled Lunaserv to support arbitrary projections for any planetary body. The LROC SOC released Lunaserv as open source in 2013 making Lunaserv available to anyone for serving planetary data using the WMS standard [3].

Capabilities: Lunaserv implements the Open Geospatial Consortium (OGC) WMS standard. The WMS standard was chosen because it is a protocol widely used by a variety of GIS software including QGIS, ArcGIS, Grass, OpenLayers, Leaflet, and JMARS. By using the WMS standard, Lunaserv can provide map data for the largest possible set of GIS data users from a single set of source data [4].

The WMS standard allows for map data to be rendered in a variety of formats, and in any SRS understood by the WMS server. A WMS SRS specifies the combination of projection and planetary body spheroid [5]. While the WMS specification recognizes only Earth-based SRS definitions, Lunaserv additionally supports the IAU2000 planetary SRS definitions, and any arbitrary SRS that can be defined using the proj.4 library [6].

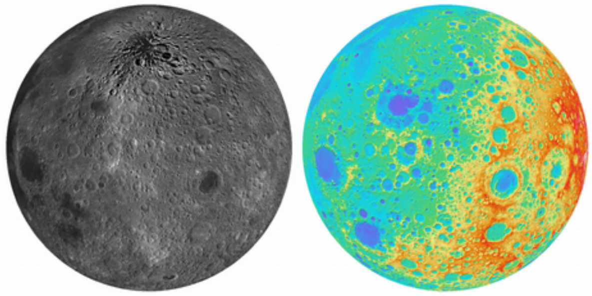

Figure 1: The Moon rendered in an orthographic projection centered at 45° N, 120° E. The left is a LROC WAC global mosaic, and the right is a color shade based on the GLD100 [11].

Lunaserv supports a variety of geographic data types.

- Raster Data (8-bit) (Fig. 1)
  - Regional
  - Global
- Vector Data (Fig. 2)
  - Points
  - Line-strings
  - Polygons
  - Annotations
  - Grids
- Illumination (Fig. 3)
  - Day/Night Shading
  - Topography-based
- Numeric (32-bit) (Fig. 4)

The raster types are loaded from pyramidal TIFFs (PTIFF). These PTIFFs can either have embedded geographic meta-data, or the geographic meta-data can be specified in a separate file. The PTIFFs can also have a 1-bit mask file to specify the area of interest within the PTIFF that should be rendered. The PTIFFs for a given layer can either be listed in the layer's configuration file, or the list can be loaded from a database.

The vector types are loaded from flat files, shapefiles, or a database.

Lunaserv supports the PostgreSQL database by default, but support for other databases is possible. All database operations support a rich set of filtering capabilities and can also used a predetermined set of 5° bins to limit the query results to the area of interest.

The illumination types render the requested illumination dynamically based on the sub-solar point

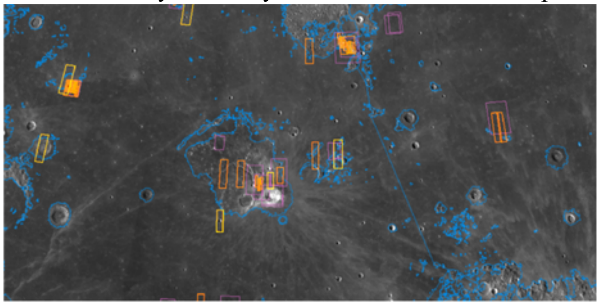

Figure 2: WAC global mosaic with ROI, DTM, Anaglyph, and shapefile RDR product layers overlaid as examples of vector layers.

calculated using the NAIF Spice toolkit [7]. For topographic-based illumination, a Digital Terrain Model (DTM) in the form of a 32-bit Integrated Software for Imagers and Spectrometers (ISIS) cube file is used to provide the necessary elevation data [8]. The illumination types will render the current illumination conditions by default, or will render the illumination conditions for any provided time or latitude/longitude sub-solar point.

The numeric type renders high-precision data types as either a 32-bit TIFF for most clients or as a 32-bit VICAR for JMARS. The source of the high-precision data is an ISIS cube. Multiple ISIS cubes of different resolutions can be provided, and Lunaserv will render each request using the ISIS cube that is the most appropriate resolution for the map request.

Usage: The LROC SOC uses Lunaserv to provide data for operations, data portals, web site context maps, PDS web interface, Where is LRO, digitizing, video generation, and other activities [9]. In addition to the ways Lunaserv is utilized by the LROC SOC, Lunaserv is also used by external users for visualization and research using a variety of GIS software packages. The public Lunaserv hosted by the LROC SOC contains all of the LROC map projected PDS products. For demonstration purposes, it additionally serves base imagery, illumination and nomenclature for Mercury, Venus, Earth, Mars, Io, Ganymede, Europe, Callisto, Rhea, Tethys, Iapetus, Dione, and Enceladus. Based on log file analysis, Lunaserv has been used by other researchers, students and the public with QGIS, ArcGIS, Google Earth, OpenSceneGraph, OpenLayers, and Leaflet [10]. On average, the public Lunaserv service hosted by the LROC SOC handles more than 20k map requests per day, and during periods of high activity, has handled over 600k map requests in a single day.

In addition to the usage of the LROC SOC hosted Lunaserv server, Lunaserv can also be installed and used by other groups to host their own map data.

Conclusion: The WMS protocol allows for GIS software users to easily combine data from multiple sources without first downloading or processing the data in any way. Lunaserv leverages this capability and extends it to provide support for the IAU2000 planetary SRS definitions, and provides support for large global data sets. By making data available using Lunaserv, research groups can make accessing their data faster and easier using software that many GIS users are already familiar with, and exposes the underlying data to uses not originally envisioned without developing custom protocols and applications.

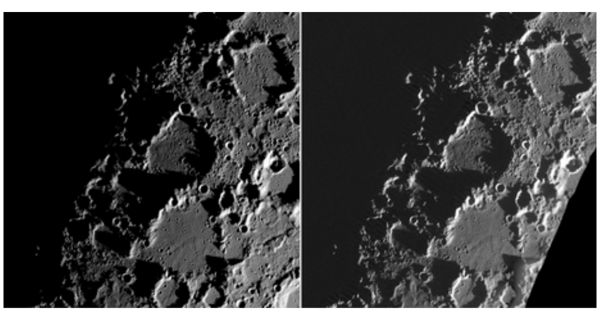

Figure 3: The north pole of the Moon on 2012-357. The left is a synthetic illumination map rendered by Lunaserv using the GLD100 DEM [11]. The right is a composite of actual LROC WAC observations from 2012-357.

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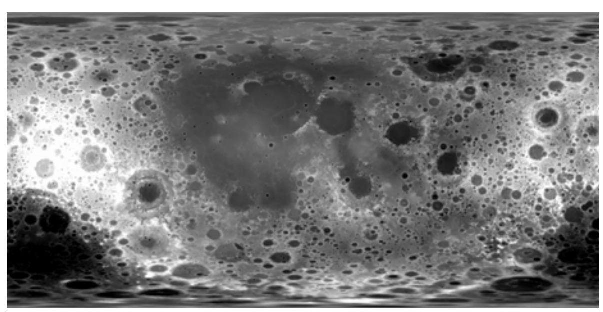

Figure 4: GLD100 DEM [11] rendered in simple cylindrical then converted to 8-bit for visual purposes using ENVI.