Scientific Writing Sample #1 – Dataset Description & GIS Integration

The first task in this project synthesizes multiple datasets (Table 1):

- DIVINER temperature,
- DIVINER-based modeled sublimation,
- Lunar Orbiter Laser Altimeter (LOLA)-based modeled illumination,
- Lyman Alpha Mapping Project (LAMP) Lyman-alpha (Ly-α) albedo,
- LAMP Off/On band ratio albedo,
- LOLA 1064 nm albedo, and
- the coordinates of water ice detections from SWIR spectral data.

The modeled illumination, LOLA NIR albedo, and LAMP UV albedo datasets were downloaded as Gridded Data Record products from the NASA Planetary Data System (PDS) and prepared for use in ArcGIS Pro using the datasets' associated PDS .LBL files. The datasets for temperature and modeled sublimation were downloaded from the UCLA DIVINER website, which contains a publicly available archive for DIVINER products and published modeling papers. The M3 water ice locations were obtained in digital form from the author. All data were projected using the lunar standard "Polar Stereographic Moon" projection for display. The data were compared to each other and to already-published maps to ensure proper registration and correct derived quantities.

	Name	Spatial Res.	Relevant Lit.	Instrument (Mission)
Environmental	Average Illumination (%)	240 mpp	Mazarico et al. (2011)	LOLA-derived
	Annual maximum temperature	240 mpp	e.g., Paige et al. (2010), Williams et al. (2019)	Diviner (LRO)
	Time-averaged temperature	240 mpp	Schorghofer & Williams (2020)	Diviner (LRO)
Surface H2O ice	Ly-α Albedo (120 nm)	240 mpp	Hayne et al. (2015); Gladstone et al. (2012)	LAMP (LRO)
	Off/On Ratio (155-190 nm/ 130-155 nm)	240 mpp	Hayne et al. (2015)	LAMP (LRO)
	1064-nm Albedo	1000 mpp	Lucey et al. (2014)	LOLA (LRO)
	Ice detections in SWIR spectral data	140 mpp	Li et al. (2018)	M3 (Chandrayaan-1)
	Annual maximum sublimation	240 mpp	e.g., Schorghofer & Williams (2020)	Diviner (LRO)
	Time-averaged sublimation	240 mpp	Schorghofer & Williams (2020)	Diviner (LRO)

Table 1. All datasets incorporated into ArcGIS Pro for the current analysis.

Illumination.

The illumination dataset is a model dataset where each cell represents average surface illumination calculated based on (1) the fraction of time that the Sun directly illuminates that cell and (2) the fractional area of the solar disk visible at that cell. Mazarico et al. (2011) used laser altimetry-derived topographic data over the lunar south pole to calculate the horizon line for each cell, and based on the horizon line, they modeled the average visibility of the solar disk at each cell location over multiple 18.6-year lunar precession cycles. The cell value represents the amount of time as a percentage that the solar disk was visible, and cells within Permanently Shadowed Regions (PSRs) have a value of 0.0. This dataset does not differentiate between half of the solar disk being visible 100% of the time (cell value = 0.5) or the entire area of the solar disk being visible 50% of the time (cell value = 0.5). I used the “Raster Calculator” to convert the digital number values into average illumination based on the information in the associated .LBL file. The range of the digital numbers is 0 to 25000, which were scaled to 0 (never illuminated) and 1 (always illuminated) by a scaling factor of 0.00004. I created a shapefile of the PSRs by reclassifying the raster to separate PSR cells from directly illuminated cells and then using the “Raster to Polygon” tool to create a polygon for each PSR.

DIVINER datasets.

The temperature datasets and their derivative products (including modeled sublimation maps) are based on measurements from the DIVINER Radiometer instrument onboard the Lunar Reconnaissance Orbiter (LRO). In the temperature datasets, each cell represents the bolometric brightness temperature, calculated from DIVINER spectral channels 3-9, which cover a spectral range of 7 – 400 microns. Radiance measurements from DIVINER are converted to brightness temperature using the Planck function:

$$B(\lambda, T) = \frac{2hc^2/\lambda^5}{e^{\frac{hc}{\lambda kT}} - 1}$$

where B is blackbody radiance,

λ is wavelength,

T is blackbody temperature,

h is Planck’s constant,

c is the speed of light, and

k is the Boltzmann constant.

The brightness temperature for each band is weighted by radiance, and then each band is summed to obtain the bolometric brightness temperature. I imported maximum temperature maps, time-averaged temperature maps, which account for diurnal and seasonal variation, and modeled sublimation maps into ArcGIS Pro for analysis.

LOLA 1064 nm Albedo.

In addition to altimetric data, LRO's LOLA instrument has an active radiometer mode that measures the power of the transmitted and received signal in nadir-pointing geometry. These measurements are used to calculate surface albedo at 1064 nm, where water ice is expected to have a higher reflectance than lunar regolith. The GDR product as it was downloaded was used for analysis without subsequent modification. The GDR is binned to 1000 m/pixel for increased signal-to-noise ratio, making this the coarsest dataset, in terms of spatial resolution, in the current analysis.

LAMP UV Albedo.

LRO's LAMP instrument measures radiance at UV wavelengths generated from interplanetary Ly-α emission and UV starlight emitted by stars in the cosmic background. The Ly-α band occurs at 119.57-125.57 nm, and the "Off" and "On" bands occur at 155-190 and 130-155 nm, respectively. Water ice has a high reflectance in the Off band but is a strong absorber in the On band and the Ly-α band, so an elevated Off/On band ratio and low Ly-α albedo with respect to the lunar regolith is diagnostic of water ice.

While the PDS has an Off/On ratio map available for download, I replicated the methods of Hayne et al. (2015), downloaded the GDRs for the Off-band albedo, On-band albedo, and their respective error maps separately, and generated the ratio manually to filter for spurious data points. Additionally, I generated the Off/On ratio error map by propagating the error from the Off-band albedo and On-band albedo error maps. That is:

$$Ratio\ Error = \frac{1}{\sqrt{\left(\frac{1}{Off\ Error}\right)^2 + \left(\frac{1}{On\ Error}\right)^2}}$$

I used the "Raster Calculator" to filter each albedo map for cell values with SNR (error) > 1, and then applied a spatial median filter with a 9x9 cell window. These filtered products were used for analysis.