A GLOBAL LUNAR CRATER DATABASE, COMPLETE FOR CRATERS ≥1 KM, II. S.J. Robbins[1]. [1]Southwest Research Institute, 1050 Walnut Street, Suite 300, Boulder, CO 80302. stuart@boulder.swri.edu

Introduction and Background: Crater catalogs for Earth's moon have been developed for over 400 years. Cataloging focused on the lunar near side until the first Soviet satellites returned images of the far side, and cataloging accelerated as better imagery and techniques became available. Catalogs have tended to focus on non-uniform cataloging of more important features rather than generating a complete census [*e.g.*, 1,2]. A few recent efforts were uniform [3-5], though the larger cataloging efforts lately have been automated [5-6]. Despite the dedicated work, these catalogs are limited in utility due to the "small" numbers of features, representing craters with diameters $D \geq 20$ km [3,4] and $D \geq 8$ km [5].

To wit, I have developed a global lunar crater database with the goal of a complete census of all impact craters as small as 1 km in diameter. This makes it comparable to a global database of Martian impact craters [7] to facilitate cross-planetary studies; it has historical significance because the lunar crater chronology – and by extension, crater chronology throughout the solar system – is defined for $N(1)$ (the spatial density of impact craters with diameters $D \geq 1$ km); and it is to a diameter where the sheer number of impacts can inform numerous lunar processes that were not previously investigable.

Crater Mapping Process and Data Used: This manual effort is the same as used for the global Martian crater database, described in [7,8]. In brief, craters are manually identified and the rims are traced in *ArcMap* software using the "streaming" tool such that many points define the rim (5 up to 8,088). These digitized rims are exported in units of decimal degrees and imported to *Igor Pro* where custom algorithms correct for all projection effects using Great Circles (lengths and bearings) [9] and fit both a circle and ellipse, saving the location, diameter, and ellipse properties (major/minor axes, tilt, ellipticity, eccentricity).

Data used started with *Lunar Reconnaissance Orbiter* (*LRO*) Wide-Angle Camera (WAC) "morphometric," "dawn" nearside, and "dusk" farside mosaics. These mosaics are 100 m/px and were used in the first search to identify most craters $D \gtrsim 1$ km. The next search used the *LRO* Lunar Orbiter Laser Altimeter (LOLA) Gridded Data Record (GDR) at 512 ppd (≈60 m/px equator) for most regions, but up to 10 m/px near the lunar poles (and required for crater identification in permanently shadowed regions). The third data set has only been employed to-date in some lunar maria and is the *Kaguya* Terrain Camera (TC) mosaics ("map," "morning," and "evening" products) with the end-game of identifying all maria craters $D \geq 0.5$ km. These are ≈20 m/px which permit good crater measurement for $D \gtrsim 0.2$ km [8]. The 2013 TC mosaics were poorly constrained to the current lunar geoid, and so small corrections must be applied based on WAC mosaics.

Progress To-Date: At the time of this submission (mid-January 2017), 1.8 *million* craters have been mapped over the entire lunar surface (1.2 million $D \geq 1$ km). Fig. 1 shows a size-frequency distribution (SFD) of catalogs relative to this new catalog. *Y*-axis values >1.0 are diameters (*x*-axis) where those catalogs have more craters, and <1.0 have fewer. [1] is clearly not a complete dataset. At $D \gtrsim 100$ km, the manual [3] and automated [5] databases agree with each other and this work, but the automated [6] found many more craters, almost certainly false positives. At $30 \lesssim D \lesssim 100$ km, [3] and [6] compare well with each other and this work, but [5] shows an offset of ~25%, also interpreted as the automated algorithm yielding false positives. The only catalog with a stated completeness ([3] of $D \geq 20$ km) shows a fall-off for craters larger than that cut-off, indicating it is not complete to that size.

Fig. 2 shows selected areas of the moon where craters $D \geq 1$ km are indicated with a dot; file size limits of this PDF make a global map unreadable.

Actively Ongoing Work: In pursuit of an awarded SSW grant, I am actively working to complete all $D \geq 0.5$ km crater mapping in the lunar maria. I am also in the process of using LOLA-registered *Kaguya* topography at 60 m/px to go through <|±60°| latitude (≈85% of the body) and include craters that were missed in the other datasets; the LOLA-registered *Kaguya* digital terrain model is very useful and it has led to the inclusion of a non-trivial number of $D \geq 1$ km impact craters (see Fig. 2 caption).

Further Expansion: Despite using four different funding sources and hundreds of hours of personal time, funds were only available to complete the above-described effort. A just-awarded PDART will allow for the calculation of topographic information and classify crater morphology, as done for Mars [7], especially classifying secondary craters. These data will allow numerous science investigations that have never before been possible.

References: [1] Arthur, *et al.* (1965). [2] Losiak, *et al.* (2009). LPSC 40 #1532. [3] Head, *et al*. (2010) doi: 10.1126/science.119505. [4] Fassett, *et al*. (2012) doi: 10.1029/2011JE003951. [5] Salamunićcar, *et al*. (2012) doi: 10.1016/j.pss.2011.09.003. [6] Wang, J. *et al*. (2015) doi: 10.1016/j.pss.2015.04.012. [7] Robbins, S.J. and B.M. Hynek (2012a) doi: 10.1029/2011JE003966. [8] Robbins, S.J. *et al*. (2014) doi: 10.1016/j.icarus.2014.02.022. [9] Vincenty, T. (1975). [10] Fassett & Thomson (2014) doi: 10.1002/2014JE004698.

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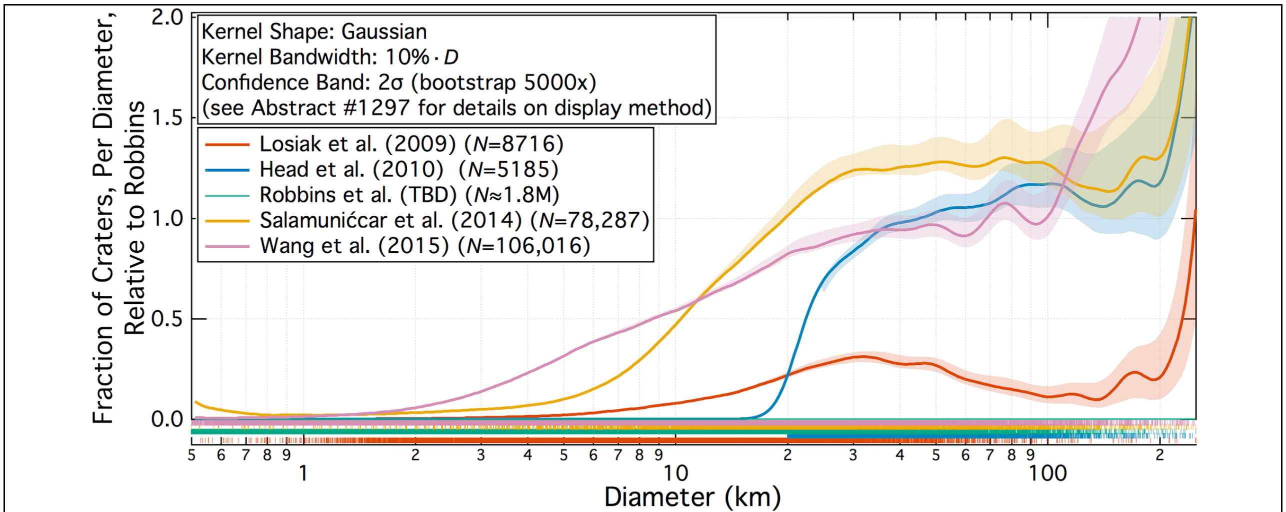

Figure 1: Crater SFDs *relative* to the catalog discussed in this abstract for select, recent crater catalogs. See Abstract #1297 (this conference) for details on the display method, including the rug plot at the bottom.

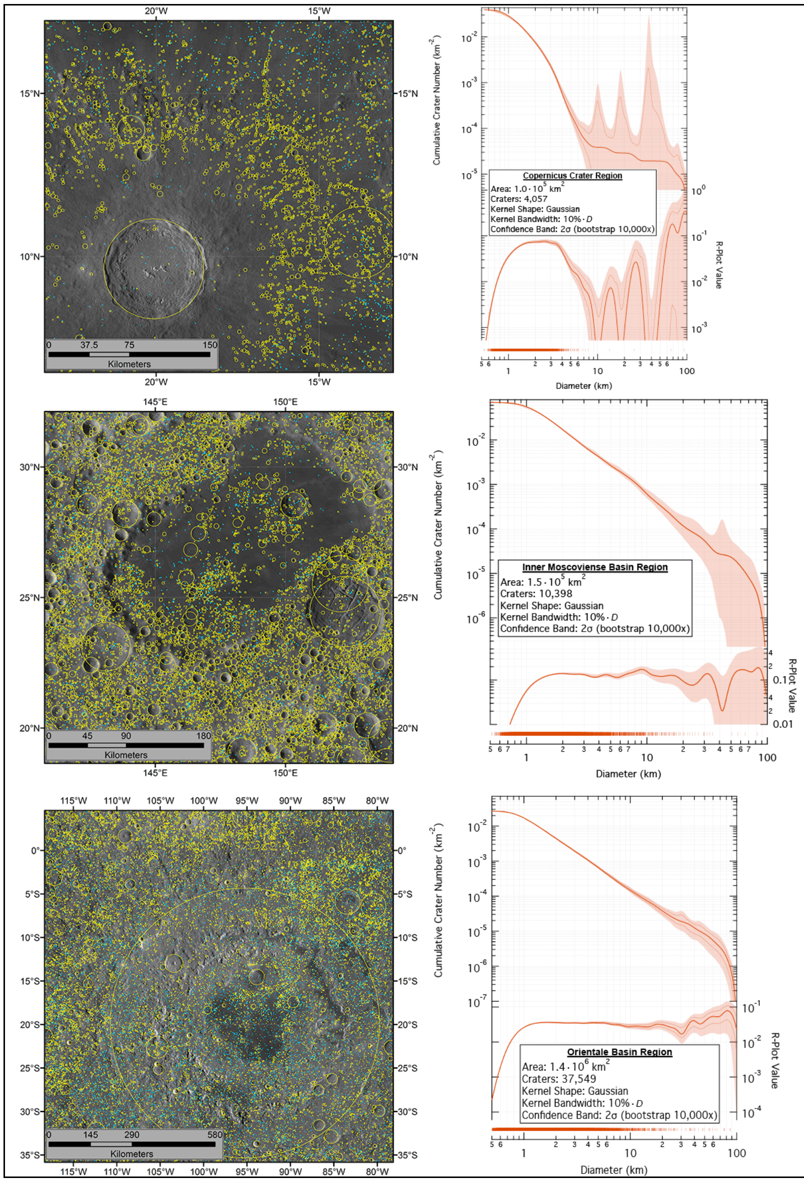

Figure 2: Example regions where craters are shown with a yellow trace ($D \geq 1$ km) or blue dot ($D < 1$ km) and cumulative and relative SFDs are shown, per the methods described in abstract #1297 (this conference); all graphs have aspect ratio 3:1 such that $\log_{10}$ horizontal is the same size as $\log_{1000}$ vertical. Basemap is LROC WAC. (top) Copernicus crater region in Oceanus Procellarum. (middle) Part of Moscoviense basin focused on Mare Moscoviense. (bottom) Orientale basin region.

SFDs *of the regions shown here* have a roll-over $D > 1$ km despite the catalog goal of all craters $D \geq 1$ km. This is currently being investigated for these regions. In particular, while mapping craters throughout the highlands regions of the moon (*e.g.*, Moscoviense and Orientale), I observed a distinct lack of craters $D \approx 1$ km. It is possible this was visual fatigue, but this was observed regardless of whether starting "fresh" in the morning or after mapping over 15,000 craters in one day. Hopefully, the TC DTMs will help answer whether this is real or due to non-obvious craters in WAC mosaics and LOLA gridded data; the rollover could be a real phenomenon, potentially due to topographic diffusion [10].

For Copernicus, the crater has a vast field of secondaries, and they and it are emplaced on young maria where most craters shown are secondaries. The SFD overturn could be due to a combination of the young maria, ejecta resurfacing, and secondary crater formation.