REFINEMENT OF THE LUNAR PRODUCTION FUNCTION – PRELIMINARY NORMALIZATION OF DATA. A. Oetting, N. Schmedemann, H. Hiesinger, University of Münster, Institut für Planetologie, Wilhelm-Klemm-Str. 10, 48149 Münster, Germany (aoetting@uni-muenster.de)

Introduction: Dating geological units on planetary surfaces is crucial to understand the geological history and evolution of celestial bodies. Tools for that are limited since direct measurements are rare. A good approach for an analysis by remote sensing was given by, e.g., Shoemaker et al. (1970), Baldwin (1971), Hartmann and Wood (1971) and Neukum (1983) with later refinements by, e.g., Neukum et al. (2001) and Ivanov et al. (2002) [1-6]. For this analysis, the crater-size-frequency distribution (CSFD) is measured on different geological units and calibrated against radiometric and exposure age data of rock and soil samples. Commonly used are the production functions (PFs) of [4] and [5], which describe the CSFD with a 11th order polynomial. However, more recent data are of significantly higher quality and methods have improved due to better understanding of key parameters such as crater scaling on various target materials or the influence of secondary cratering. We aim to perform a further refinement of the PF, which will benefit from higher resolution image data (up to 0.5 m/pixel) [7] and the consideration of target properties and scaling. Additional information such as spectral data will be used to separate different geological units, reducing the risk of getting mixed crater retention ages.

Studies that have investigated the strength-to-gravity-transition in combination with target properties point out that small craters in the strength-regime are highly influenced by target properties. However, at which crater diameter the transition appears is debated in the literature: Prieur (2017) [8] sets it between 200 m and 400 m on the lunar mare, Van der Bogert et al. (2017) [9] at around 1 km and Schulz and Spencer (1976) [10] at about ≤ 3 km. The study of [9] at Jackson crater found out that the crater diameter is 20% larger in the ejecta material than in the melt pool material. This leads to a potential distortion of the determined age when using Neukum’s PFs for small craters that are strength-dominated.

This work focuses on the implementation of additional parameters (e.g. strength- to gravity-scaling, target properties) to obtain improved absolute model ages and to extend the valid crater diameter from 10 m to 300 km [4] to a larger diameter range. An essential step for that is the normalization to find a function which fits the data best.

Method: For initial analysis we used crater counts from the crater catalog of Head et al. (2010) [11] with minor adjustments of crater diameters. They counted craters equal to or larger than 20 km based on elevation data from the Lunar Orbiter Laser Altimeter [11, 12]. The CSFD was determined with the ArcGIS CraterTools add-in by Kneissl et al. (2010) [13]. The .stats-files of the CSFD measurements, created with the Software CraterStats [14], were used to normalize the data. In our approach, we identified measurements with lowest possible modification by secondary cratering or resurfacing events. We sorted the measurements by the size of their largest populated crater bin size in pseudo-log binning [4] and vertically normalized the measurements consecutively. In this process the measurement with the largest crater bin size was used as a reference. The adjacent measurement with the second-largest crater bin size was then vertically shifted to minimize the offsets in cumulative crater frequencies due to different crater retention ages. After the position with the minimum offset was found, the next measurement with the third largest crater bin was normalized to the previous one until all measurements were normalized. We then calculated the median cumulative crater frequency for each diameter bin. This procedure reduces random noise in each crater bin especially in less populated larger diameter bins. This processing has been developed specifically to accommodate later measurements at smaller crater sizes as well. Then measurements will span across 4 or even 5 orders of magnitude in diameter and smallest diameter measurements may not overlap with large diameter measurements anymore. Finally, the normalized and averaged CSFD will be fitted by the best matching polynomial, thus it can be used with the CraterStats software and its shape can be published via the polynomial coefficients.

The normalized plot consists of four different highland measurements (Fig. 1) including 699 craters.

Figure 1: For preliminary testing, crater counts from the crater catalog of [11] were used with minor modifications. The selected areas are shown in blue.
Results: Figures 2 and 3 show the CSFD of the individual areas and the normalized CSFD with the cumulative crater frequency in pseudo-log binning.

![Display of the individual CSFDs, the normalized data points (red dots) and the PF of [4] (red polynomial) for orientation. The vertical lines of individual data points represent their error bars.](image1)

Figure 2: Display of the individual CSFDs, the normalized data points (red dots) and the PF of [4] (red polynomial) for orientation. The vertical lines of individual data points represent their error bars.

![Displayed is the isolated normalized CSFD with the PFs of [4] and [5]. The PF of [5] is valid for crater diameters up to 100 km. The light gray straight line represents the equilibrium function of Trask (1966) [15].](image2)

Figure 3: Displayed is the isolated normalized CSFD with the PFs of [4] and [5]. The PF of [5] is valid for crater diameters up to 100 km. The light gray straight line represents the equilibrium function of Trask (1966) [15].

The plots of the individual CSFDs of areas 1 to 4 show similar shapes among themselves. They all follow Neukum’s PF very well, especially at smaller crater diameters. Larger crater diameters reveal an increased scattering. However, this effect is minor and results from the small number of larger craters and the associated poorer statistics.

The normalized CSFD also follows the trend of Neukum’s PFs. However, a kink is present at ~130 km, which might suggest a resurfacing event. This indicates that the counting areas, which should be as homogenous and unmodified as possible, have not yet been optimally selected.

Next steps: As already mentioned, this abstract only marks a starting point for future analyses. So far, we have only normalized craters that have a diameter of ≥ 20 km, taken from the crater catalog of [11], and which are not located on fundamentally different geological units. Next we will perform our own crater counts on various geological units to obtain a normalized CSFD over a wide crater diameter range. For a further refinement of the PF for small craters, target properties and scaling characteristics will be considered.

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References: