AN ARCGIS INDEPENDENT APPLICATION TO CONDUCT CRATER SIZE-FREQUENCY MEASUREMENTS WITH RESPECT TO CRATER OBLITERATION EFFECTS.

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Introduction: Crater size-frequency distributions (CSFDs) have long been used to analyze and date planetary surface processes [1-4]. To derive such information from remote sensing data, impact craters on a geologically homogeneous surface [5] are processed by crater counting techniques [6-9]. There are two well-established techniques, Traditional Crater Counting (TCC) and Buffered Crater Counting (BCC) [6-8], and two new techniques, Non-sparseness Correction (NSC) and Buffered Non-sparseness Correction (BNSC) [9]. The well-established TCC and BCC techniques are implemented in the ArcGIS Add-In CraterTools [6]. Together with ArcGIS, the tool provides an environment for the visual identification of impact craters and the application of the well-established crater counting techniques. CraterTools is written in VB.NET and uses Esri's ArcObjects library for geodesic measurements. It is thereby limited to 32 bit and single-core computing. The new crater counting techniques; however, require more complex polygon modifications and cannot be implemented efficiently in CraterTools.

To overcome the given limitations, we developed a new software tool for the application of crater counting techniques. The new tool is optimized for multi-core data processing and uses the open GDAL library for handling geospatial data. However, in contrast to the ArcGIS environment, GDAL's functions for geospatial measurements don't take the effect of a curved three-dimensional planetary surface into account. Instead, measurements are conducted with respect to a two-dimensional map-projection. This would make the application of crater counting techniques prone to map distortion effects. Hence, in order to give precise and consistent results, we developed technical and geospatial workarounds to apply the necessary measurements and polygon modifications with respect to a curved planetary surface.

Review of the BNSC Approach: Crater counting techniques determine which craters are considered for the crater size-frequency measurements and which reference area is assigned to each crater. In the BNSC approach [9], the effect of crater obliteration by larger impact craters is considered. For every crater that intersects the count area, all larger craters plus their surrounding ejecta blanket areas are erased from the initial reference area polygon. The remaining area is then buffered by the radius of the currently investigated crater (Figure 1). This implies that on densely cratered

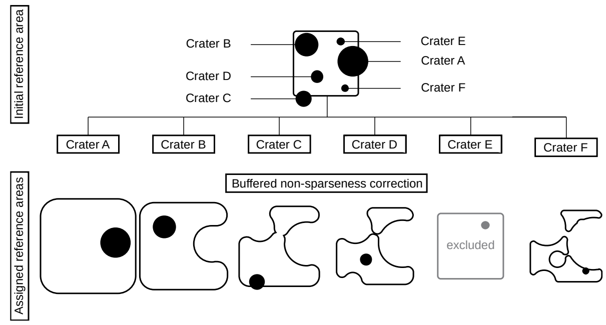

Figure 1: *Assigned reference areas for six craters A-F during BNSC.*

surfaces, small impact craters are only counted on areas which were unaffected by crater obliteration and subsequent recratering.

Effects of BNSC on the CSFD: BNSC leads to a decrease in reference area size with decreasing crater diameter. This increases the crater density of small diameter craters in the CSFD plot when compared to the well-established crater counting techniques. To demonstrate this effect, we used BCC and BNSC to investigate the CSFD for a densely cratered area north of Malapert Massif on the lunar nearside (Figure 2A). BNSC leads to an upward shift of crater frequencies for small diameter craters (Figure 2B). In return, a larger diameter range can be used to fit the lunar production function, making the observation on densely cratered surfaces more consistent with observed crater formation rates [10].

Effects of Cartesian Measurements on the CSFD: Geospatial operations in GDAL are conducted on a two-dimensional Cartesian plane. Accordingly, the results are affected by map distortion effects. Since impact craters are investigated on a curved planetary surface, this would lead to inaccurate and inconsistent results during crater counting. When BNSC is applied using geodesic measurements (on a three dimensional body) and measurements in equirectangular and Mercator projections (on a two dimensional body), different CSFDs for the reference area north of Malapert Massif can be observed (Figure 2C). The results from the Mercator projection are inconsistent with the lunar production function. While the results from the equirectangular projection yield the same absolute age for the reference area as the geodesic measurement, the shape of the CSFD varies significantly between the

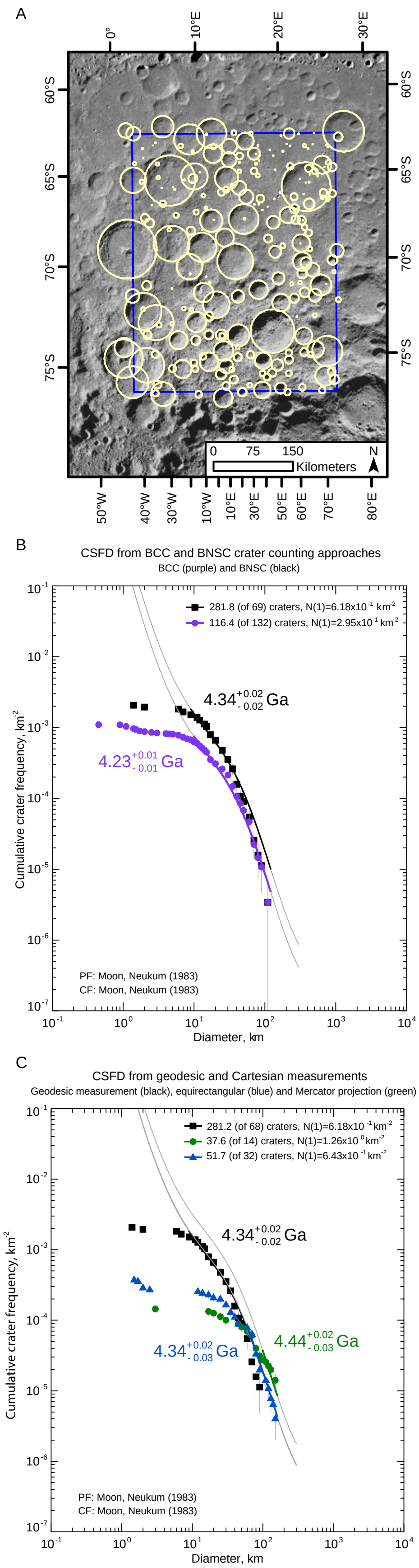

Figure 2: *Reference area north of Malapert Massif on the lunar nearside (blue) with intersecting impact craters (yellow) from the LU78287GT crater catalogue [11] (Fig. 2A). The application of BCC (purple) and BNSC (black) crater counting techniques result in different CSFDs (Fig. 2B). CSFDs from measurements in two dimensional equirectangular (blue) and Mercator projections (green) show inconsistencies with the lunar PF when compared to geodesic measurements (black) (Fig. 2C).*

two. The geodesic measurement on the other hand results in a CSFD which is largely consistent with the lunar production function.

Implementation: The inconsistencies that occur when geospatial measurements are conducted on a Cartesian plane demonstrate the requirement for geodesic workarounds. To this end, we implemented a number of approaches for geodesic polygon alterations and measurements. This includes the geodesic buffering of polygons, geodesic measurements of area size, distance and azimuth on a biaxial ellipsoid as well as the automatic handling of dateline intersections. The new standalone tool supports multi-core data processing and uses two input shapefiles for crater counting. The procedure is independent from the attributes of the shapefiles. Accordingly, the digitization of reference area and impact craters can be conducted in any Desktop GIS. The data processing results in an SCC text file for further statistical analysis in the Craterstats [12] software.

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