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Crater size-frequency distribution measurements with CSFD Tools

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Abstract

The analysis of crater size-frequency distributions (CSFDs) is a widely used technique to date and investigate planetary surface processes. For areas of high crater density, there are new geometric corrections that consider the effects of crater obliteration and subsequent recratering while measuring CSFDs. The new corrections require computationally intensive modifications of polygon geometries with respect to a curved planetary surface. Thus, in order to efficiently implement the new approaches in a software tool, we developed CSFD Tools, an application to conduct CSFD measurements from shapefiles. Our tool supports 64 bit and multi-core data processing and uses workarounds for the geodesic modification of polygon data. As a result, the new geometric corrections can be applied through a software tool.

1. Introduction

Absolute and relative ages of planetary surfaces have long been determined by statistical analyses of crater size-frequency distributions (CSFDs) [1,2]. The CSFD of a given surface unit is obtained by the application of CSFD measurement techniques. Such techniques describe which craters are included in the process and which reference area is assigned to each crater. There are two well-established techniques, traditional crater counting (TCC) and buffered crater counting (BCC) [3-5], and two new geometric corrections, non-sparseness correction (NSC) and buffered non-sparseness correction (BNSC) [6,7]. The new NSC and BNSC approaches are applied to consider the effect of crater obliteration by larger impact craters.

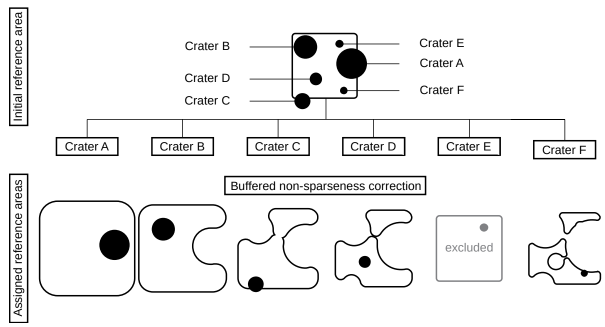

Figure 1: Assigned reference areas for six craters A-F during BNSC.

2. Review of the BNSC approach

The elimination of small craters through a larger impact crater can affect the shape of the CSFD and lead to variations when compared to observed crater formation rates [6]. To consider this effect when CSFD measurements are applied, larger craters plus their surrounding ejecta blankets are excluded from the reference area in the BNSC approach. The radius of a crater that is currently under investigation is used to buffer the remaining area (Figure 1). This implies that on densely cratered surfaces, small impact craters are only counted on areas which were unaffected by crater obliteration and subsequent recratering.

3. Implementation

We developed CSFD Tools to implement the new geometric corrections in a software tool that allows 64 bit and multi-core data processing. The tool uses open geospatial libraries to conduct GIS operations. However, current open geospatial libraries only allow geospatial operations on a two-dimensional Cartesian plane. Since impact craters are investigated on a curved planetary surface, this would lead to inaccurate results when CSFD measurements are applied. To this end, we implemented a number of approaches for geodesic polygon modifications 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 Date Line intersections.

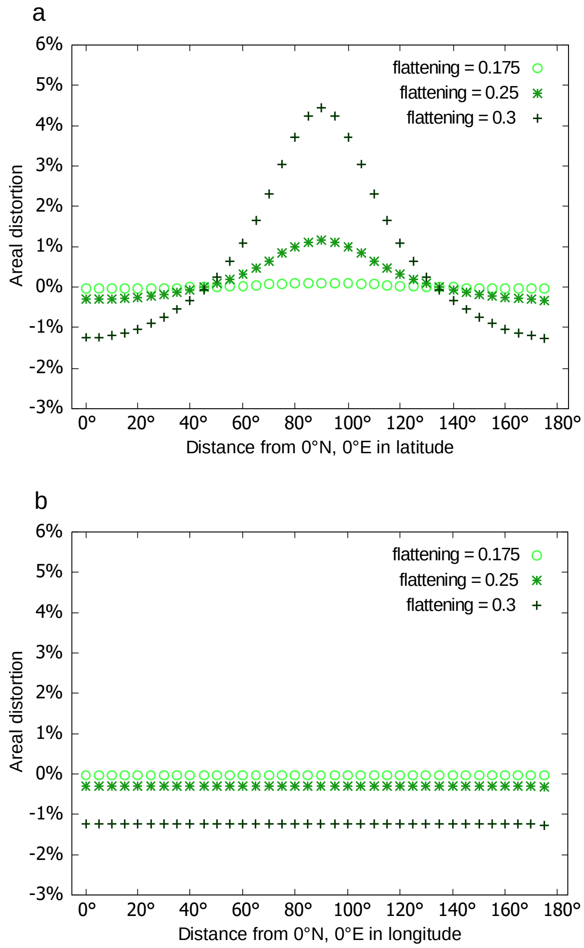

Figure 2: Distortion of area measurements in LAEA projection with growing eccentricity of the reference body. Measurements were conducted along the central meridian (Fig. 2a) and the equator (Fig. 2b).

4. Accuracy

The implemented methods for the consideration of a curved planetary surface include geodesic measurements of distance and azimuth as well as area measurements using Lambert azimuthal equal area projection (LAEA). The implemented geodesic measurements are accurate within 0.000015” on the reference body that is used [8]. To assess the accuracy of area measurements, we applied Tissot indicatrices [9] of a fixed size and investigated the area distortion depending on its location and the eccentricity of the planetary reference body (Fig. 2). We found that distortions increase with growing distance from the equator and increasing eccentricity of the reference body. We consider the implemented methods valid for CSFD measurements on planetary bodies that can be approximated by a biaxial ellipsoid with a flattening of 0.3 or lower with a precision of better than 5%.

5. Conclusions

CSFD Tools is available as an executable Windows application and does not require any further software installations. The tool supports 64 bit and multi-core data processing and uses two input shapefiles for CSFD measurements. 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 software.

Acknowledgements

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