Crater Counting on Heavily Cratered Surfaces: Implementing Non-sparness Correction in an ArcGIS Independent Tool for Planetary Surface Dating

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Impact craters on the lunar surface

Old Surface

Young Surface

LROC WAC Imagery
Towards absolute surface ages in three steps

1. Digitization

2. GIS Analysis / Crater Counting

   ArcGIS Add-In CraterTools
   (Kneissl et al. 2011)

   Image source: Kneissl et al. (2016)

   Well-established techniques

   New techniques

3. Statistical Analysis

   Craterstats
   (Michael et al. 2010)

Image source: Kneissl et al. (2016)

Data source: Fassett et al. (2012), Head et al. (2010)
Well-established crater counting approaches

Traditional Crater Counting

- Every crater with centroid in reference area is counted
- Research area remains unchanged
- Every crater is equally considered

Initial reference area

Assigned reference area

Excluded
Well-established crater counting approaches

Buffered Crater Counting

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<tr>
<th>Initial reference area</th>
<th>Assigned reference area</th>
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- For every crater, the reference area is extended by $x \times$ crater radius
- Every crater with centroid within extended reference area is counted
- Improvement of statistics: Using additional craters which superpose the reference area
Consideration of resurfacing by large impact craters

We don't know how many smaller craters were eliminated by the larger crater + ejecta blanket → Formation rate of smaller craters in this area is unknown

On heavily cratered surfaces, the rate of crater formation (Production function) may differ from the observed number of craters
For every crater, all craters with larger radius are extended by 1 * radius and erased from the reference area.

Reference area gets smaller for small craters → weight of small craters increases.

Used to consider resurfacing from impact craters.

Non-sparseness Correction

New crater counting approaches (Kneissl et al. 2016)
New crater counting approaches (Kneissl et al. 2016)

- Combination of Buffered Crater Counting and Non-sparseness correction
- Improvement of statistics by using additional craters which superpose the reference area
- Used to consider resurfacing from large impact craters

Buffered non-sparseness Correction

Initial reference area
- A
- B
- C
- D
- E

Assigned reference area
- A
- B
- C
- D

Computationally intensive
Effects on crater size-frequency distribution

Buffered Non-Sparseness Correction better represents the Production Function!
Results from Buffered Non-Sparseness Correction: Orgel et al. (2017)

Buffered Crater Counting

Buffered Non-sparseness Correction

Crater Size-frequency Distribution of pre-Nectarian, Nectarian and Imbrian Lunar Basins

Data by Fassett et al. (2012) & Head et al. (2010), Buffered Crater Counting by Orgel et al. (2017)

Pre-Nectarian: $4.2^{+0.0}_{-0.0}$ Ga
Nectarian: $4.1^{+0.0}_{-0.0}$ Ga
Imbrian: $3.8^{+0.0}_{-0.0}$ Ga

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PF: Moon, Neukum (1983)
CF: Moon, Neukum (1983)
What do we have? What do we need?

1. Digitization
2. GIS Analysis
3. Statistical Analysis

Implemented in CraterTools
Not Implemented in CraterTools

Image source: Kneissl et al. (2016)
Why not implement the new approaches in CraterTools?
Limitations due to ArcObjects performance

**CraterTools (Current Tool)**
- Only 32 bit & singlecore computation
- Low performance of ArcObjects
- Non-sparseness correction & Buffered non-sparseness correction require more complex computations
- Both approaches cannot be implemented efficiently

**New Tool (under development)**
- 64 bit and & multicore computation
- Implementation of non-sparseness correction and buffered non-sparseness correction
- Bonus: Automated handling of dateline and polar intersections & Shapefile output
- Open software libraries
What needs to be considered for crater counting?

- Geodesic distance calculations
- Geodesic buffering of polygons
- Treatment of self-intersecting polygons
- Geodesic area calculations
- Dateline intersections of polygons
- Polar intersections of polygons
- Multicore support
- ...

...
Development Status

Implemented

Traditional Crater Counting
Buffered Crater Counting
Non-sparseness Correction
Treatment of Dateline Intersections
Shapefile Output
Multicore Computation

Not yet implemented

Buffered Non-sparseness Correction
Treatment of Polar Intersections
Graphical User Interface
Conclusion and Next Steps

Role of the new tool:

• Consider influence of crater obliteration on crater size-frequency analysis
• Performance gain mandatory for Non-sparseness correction and Buffered non-sparseness correction. Performance of ArcObjects is too low to efficiently conduct analyses.

Next Steps:

• Implementation of Buffered non-sparseness Correction
• Treatment of polar intersections
• Graphical User Interface
Thanks for your attention
References


