DFG

TRR 170
LATE ACCRETION
ONTO TERRESTRIAL PLANETS

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

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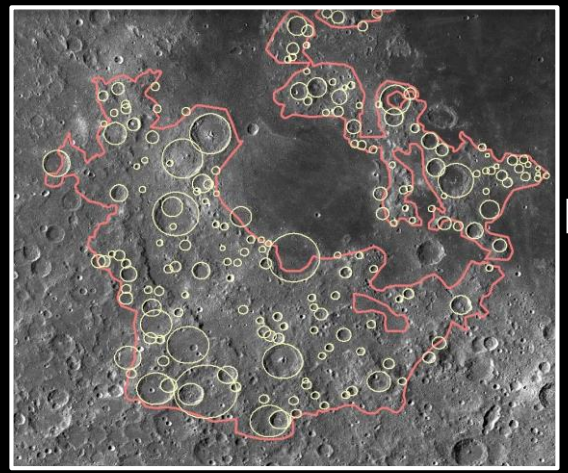
Impact craters on the lunar surface

0 25 50 Kilometers

LROC WAC Imagery

Towards absolute surface ages in three steps

1. Digitization



Data source: Fassett et al. (2012), Head et al. (2010)

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

2. GIS Analysis / Crater Counting

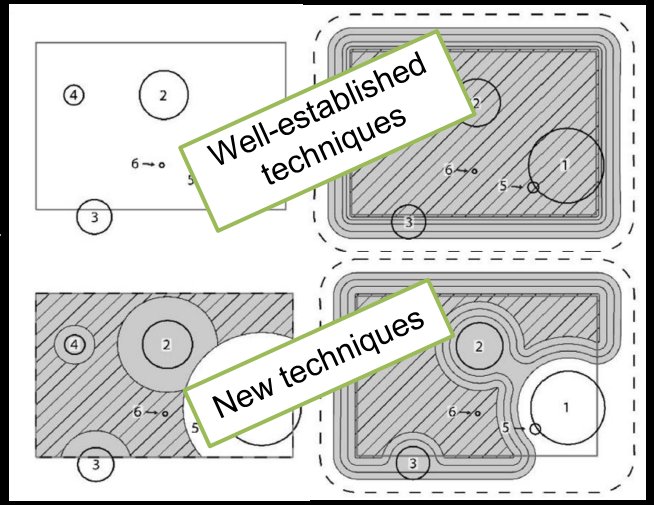
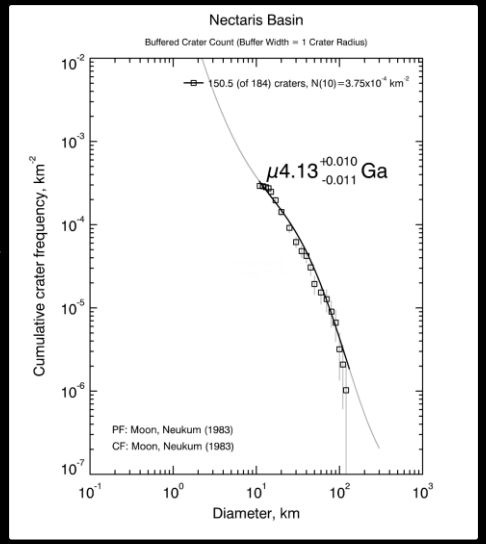


Image source: Kneissl et al. (2016)

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

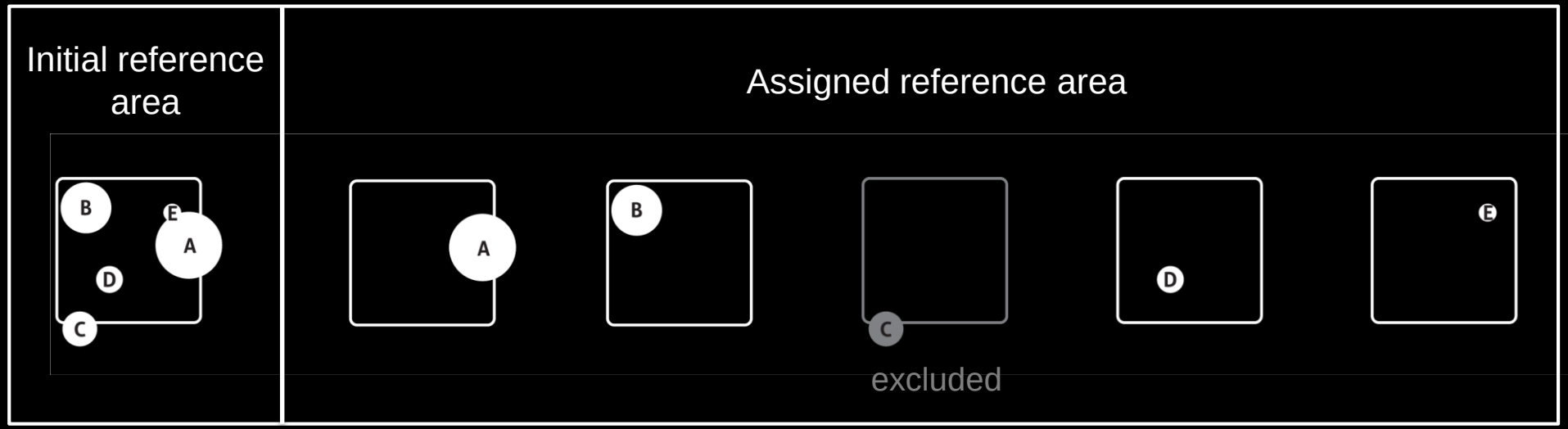
3. Statistical Analysis



Craterstats
(Michael et al. 2010)

Well-established crater counting approaches

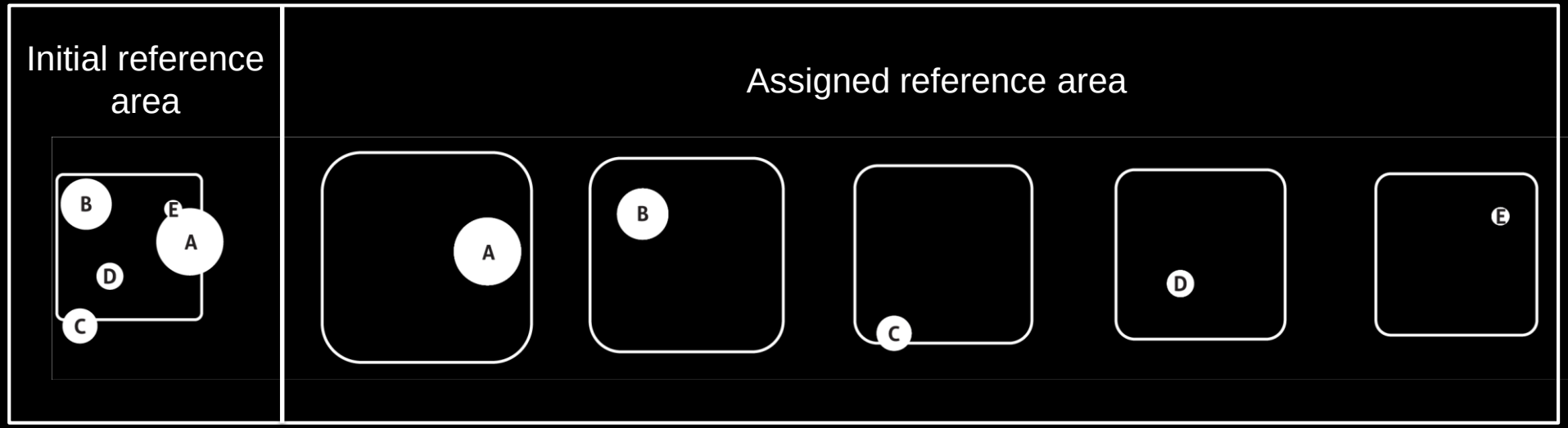
Traditional Crater Counting



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

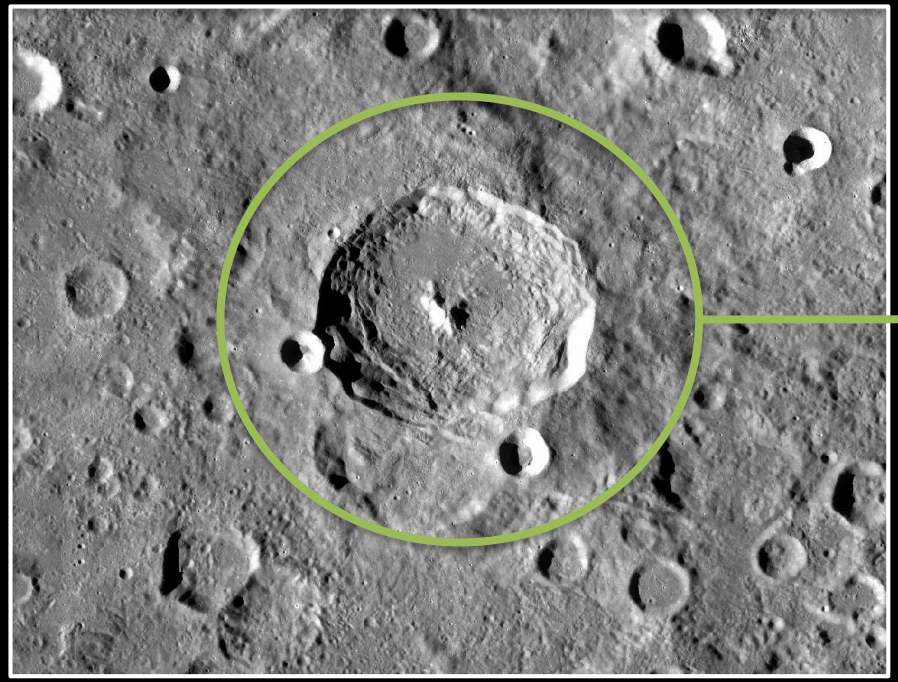
Well-established crater counting approaches

Buffered Crater Counting



- For every crater, the reference area is extended by x * 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

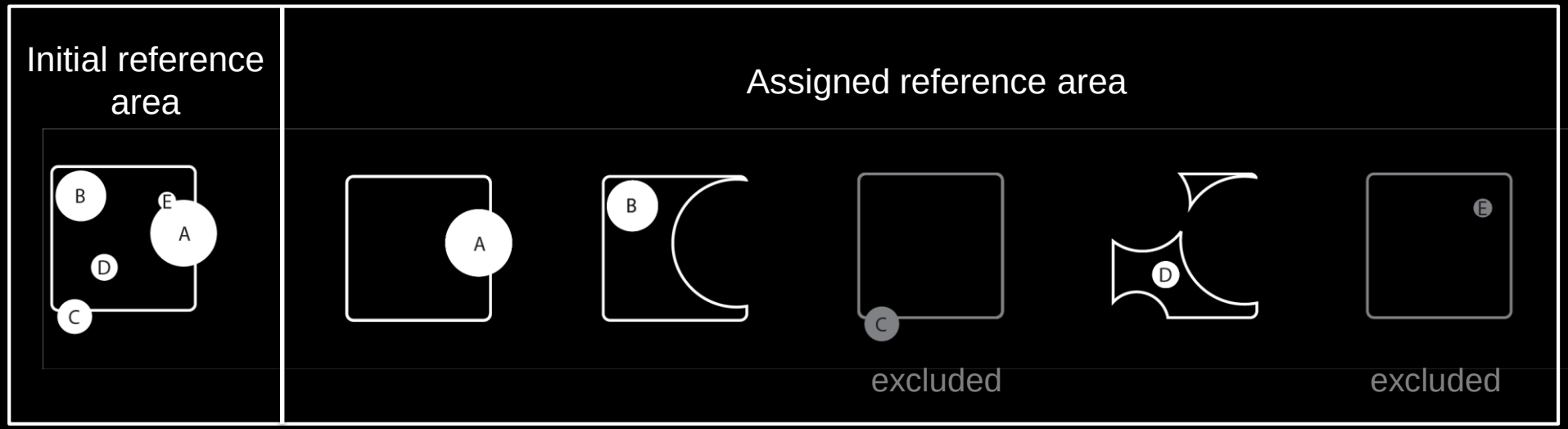
→ Formation rate of smaller craters in this area is unknown

On heavily cratered surfaces, the rate of crater formation (Production function) may differ from the observed number of craters

LROC WAC Imagery

New crater counting approaches (Kneissl et al. 2016)

Non-sparseness Correction

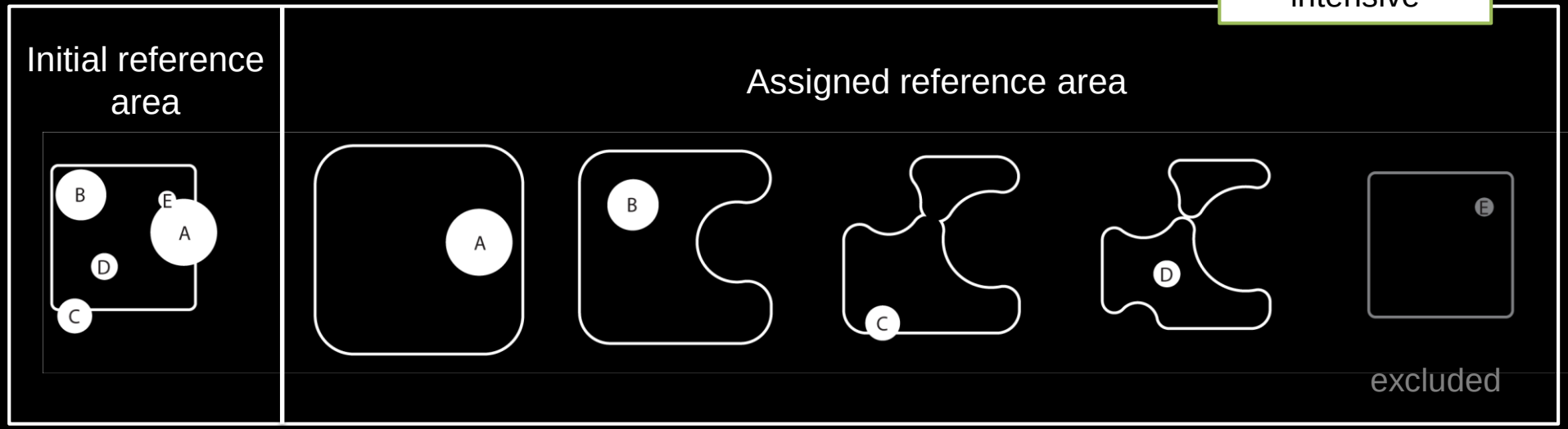


- For every crater, all craters with larger radius are extended by 1 * radius and erased from the reference area
- Reference area gets smaller for small craters → weight of small craters increases
- Used to consider resurfacing from impact craters

New crater counting approaches (Kneissl et al. 2016)

Buffered non-sparseness Correction

Computationally intensive

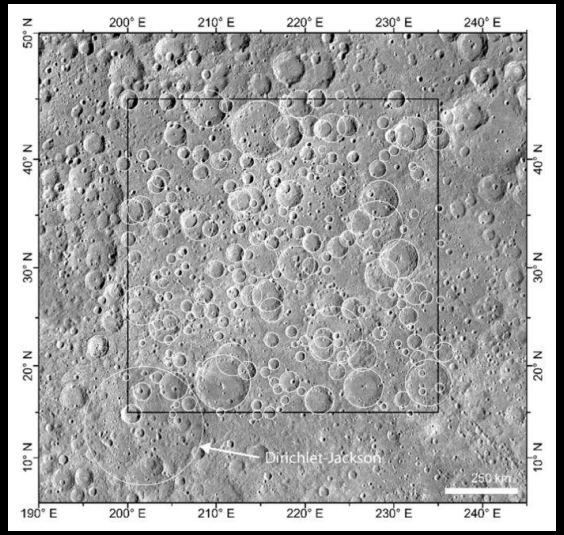


- Combination of Buffered Crater Counting and Non-sparseness correction
- Improvement of statistics by using additional craters which superpose the reference area
- Used to consider resurfacing from large impact craters

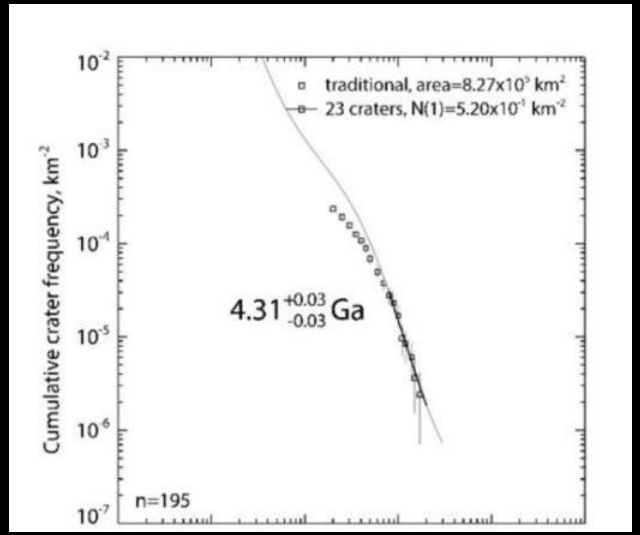
Results from Buffered Non-Sparseness Correction (Kneissl et al. 2016)

Effects on crater size-frequency distribution

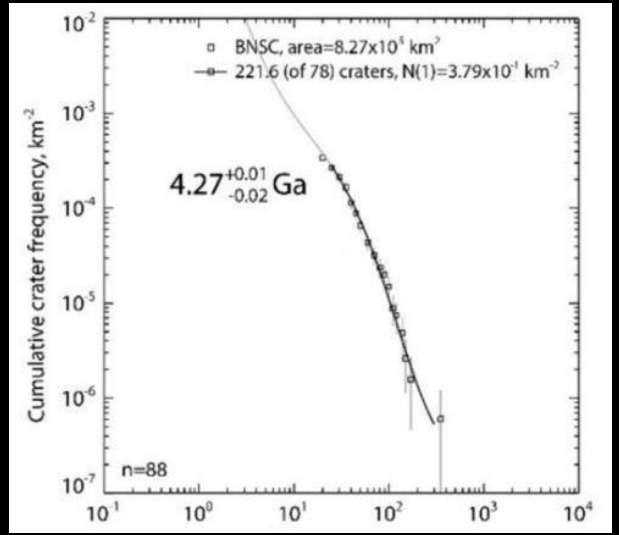
Heavily Cratered Surface



CSFD from Trad. Crater Counting



CSFD from BNSC

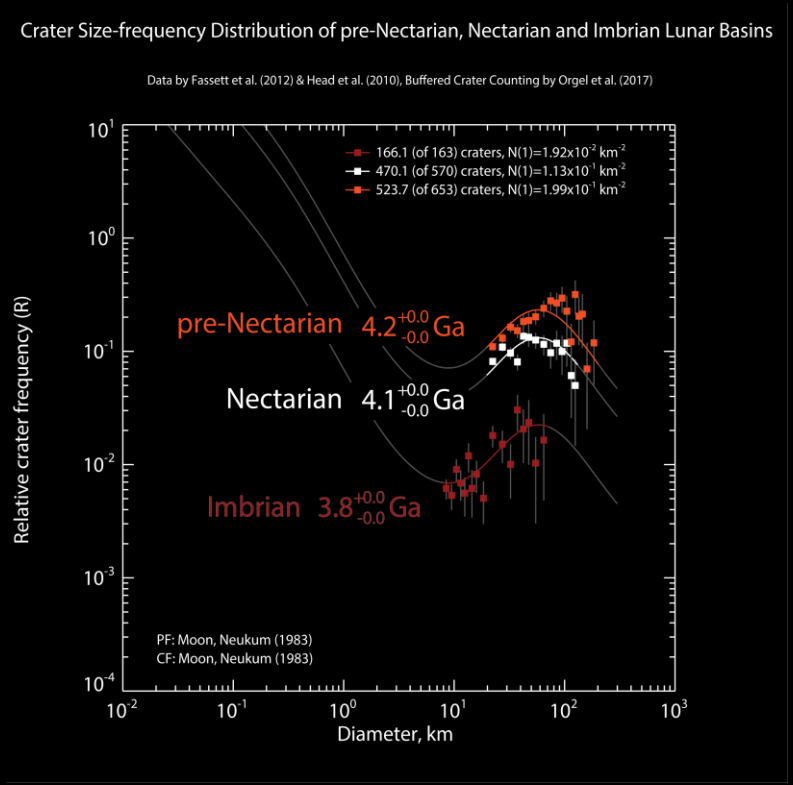


Buffered Non-Sparseness Correction better represents the Production Function!

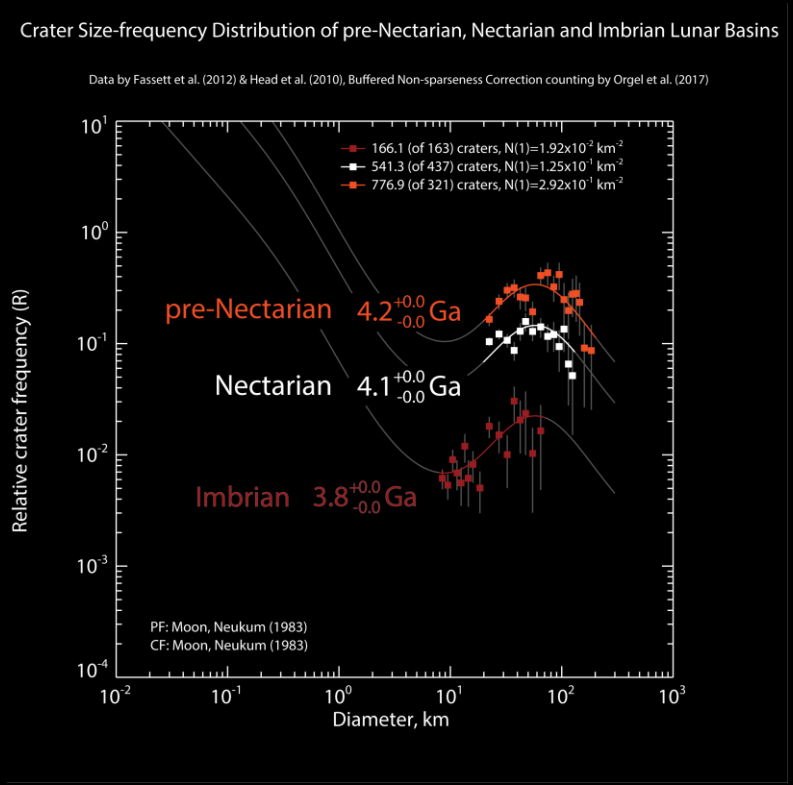
Image sources: Kneissl et al. (2016)

Results from Buffered Non-Sparseness Correction: Orgel et al. (2017)

Buffered Crater Counting

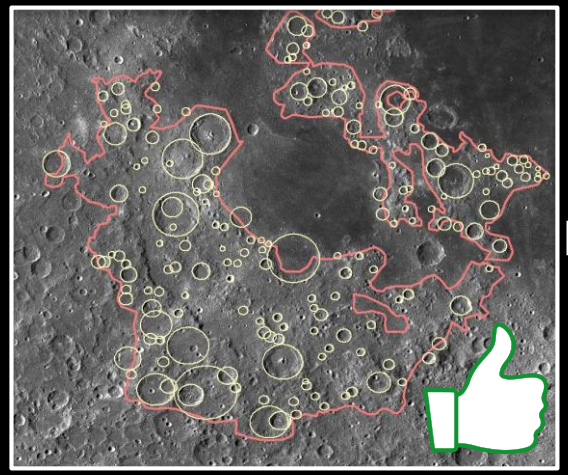


Buffered Non-sparseness Correction



What do we have? What do we need?

1. Digitization



2. GIS Analysis

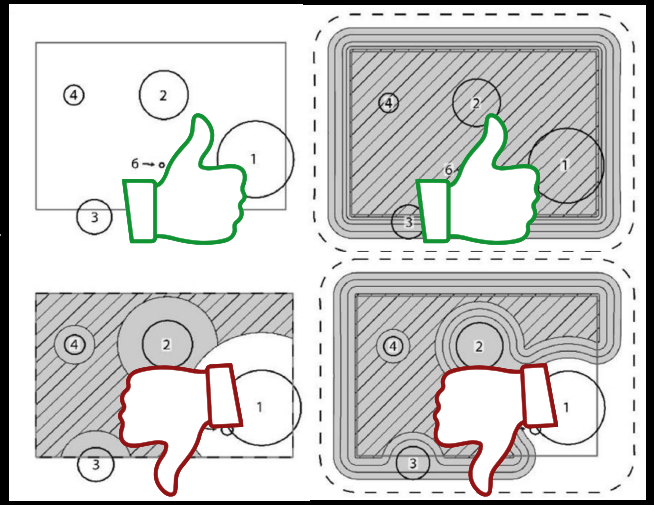
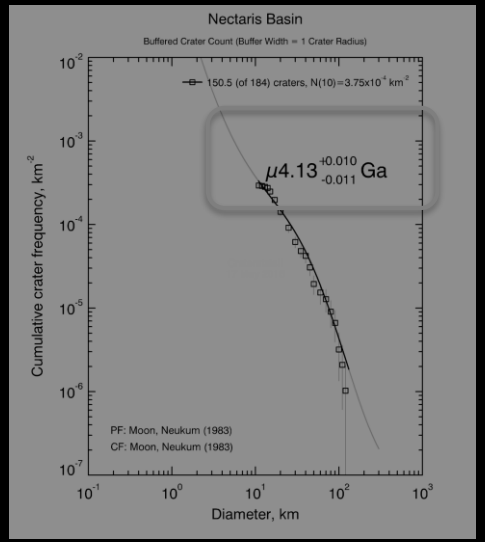


Image source: Kneissl et al. (2016)

3. Statistical Analysis



Implemented in CraterTools

Not Implemented in CraterTools

Why not implement the new approaches in CraterTools?

Limitations due to ArcObjects performance

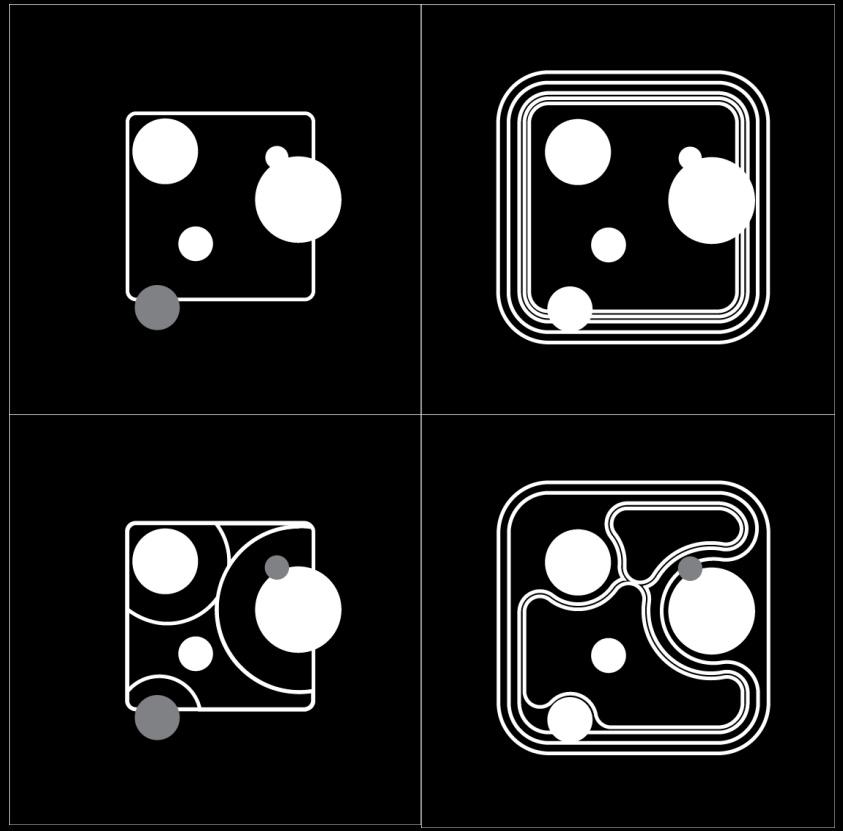
CraterTools (Current Tool)

- Only 32 bit & singlecore computation
- Low performance of ArcObjects
- Non-sparseness correction & Buffered non-sparseness correction require more complex computations
- Both aproaches 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

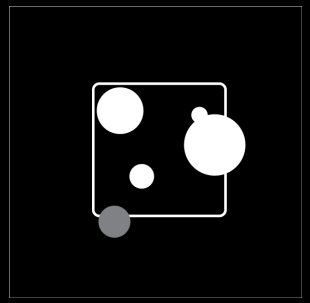
Buffered Crater Counting

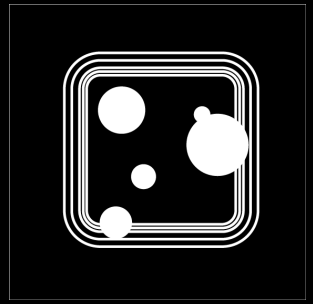
Non-sparseness Correction

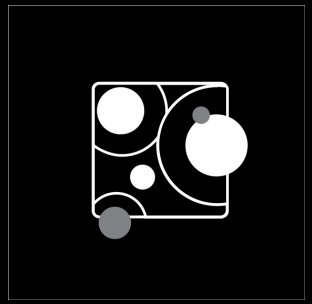
Treatment of Dateline Intersections

Shapefile Output

Multicore Computation





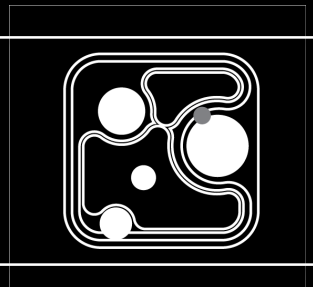


Not yet implemented

Buffered Non-sparseness Correction

Treatment of Polar Intersections

Graphical User Interface



Conclusion and Next Steps

Role of the new tool:

- Consider influence of crater obliteartion 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

Fassett et al. 2012. Lunar impact basins: Stratigraphy, sequence and ages from superposed impact crater populations measured from Lunar Orbiter Laser Altimeter (LOLA) data. Journal of Geophysical Research 117 (E12).

Head J. W. et al. 2010. Global Distribution of Large Lunar Craters: Implications for Resurfacing and Impactor Populations. Science, 329, 1504-1507.

Kneissl T. et al. 2011. Map-projection independent crater size-frequency determination in GIS environments – New software tool for ArcGIS. Planetary and Space Science 59: 1243-1254.

Kneissl T. et al. 2016. Treatment of non-sparse cratering in planetary surface dating. Icarus 277: 187-195.

Michael G.G. Et al. 2010. Planetary surface dating from crater size-frequency distribution measurements: Partial resurfacing events and statistical age uncertainty. Earth and Planetary Science Letters 294 (3-4): 223-229.

Neukum G. and Ivanov B. A. 1994. Crater size distribution and impact probabilities on Earth from lunar, terrestrial-planet, and asteroid cratering data. Hazards Due to Comets and Asteroids: 359–416.

Orgel et al. (2017) Ancient Bombardment of the Inner Solar System – Reinvestigation of the “Fingerprints” of Different Impactor Populations on the Lunar Surface. LPSC XLVIII, Abstract #1033.