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Geomorphometry of simple crater degradation classes on mare Serenitatis

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Abstract

The classification of impact crater degradation is performed through a subjective visual interpretation of lunar surface images [1]. Here we propose an alternative quantitative methodology based on a morphometric analysis of simple impact craters carried out on high resolution digital terrain models (DTM). Our results have provided a quantitative distinction among different crater classes and have shown common trends of degradation, in function to diameter. The statistical analysis of crater morphometry allowed us to constrain the degradation classes in a 3D diagram that clearly shown a cluster distribution of the four degradation classes.

1. Introduction

In this study we have applied 3D morphometric analysis on high resolution DTMs, derived from LROC Narrow Angle Camera (NAC) that provide a resolution range from 0.5 to 2 m/pixel and Kaguya-Selene (JAXA), that provided a global DTM with a resolution of 7 to 10 m/pixel.
Morphometric analysis pointed to the calculation of the first two elevation derivatives (slope and curvatures) and their statistical distribution. In particular curvatures were retrieved by applying a multiscalar approach [4], in order to reduce DTM building and interpolation errors. Multiscalar approach was applied both to Kaguya TC DTMs and LROC-NAC DTMs. For the LROC NAC DTMs every kernel sizes from 3x3 to 99x99 were calculated. On LROC DTMs those kernel sizes correspond to windows sizes ranging from 6m2 to 198m2. The more favorable kernel resulted the 33x33 one, which coincides to a windows area of 66m^2, as shown in fig.1. For the Kaguya TC DTMs every kernel sizes from 3x3 to 33x33 were tested and the best size calculated was the 15x15 one, which corresponds to a 150m^2 window area (fig.1).

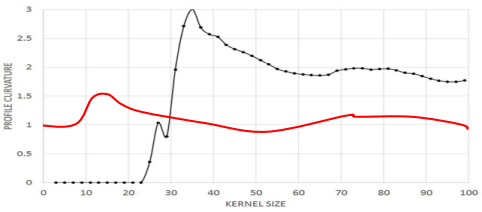

Figure 1: Plots of the maximum expression of the profile curvature at different evaluation kernel sizes for the LRO DTM (black line) and for the Kaguya DTM (red line), testing every kernel sizes from 3×3 to 99×99. For the LRO DTMs were estimated the peak of profile curvature expression on kernel 33, whereas for the Kaguya DTM on kernel 15.

2. Morphometric signature of a fresh impact crater

We firstly derived and measured the morphological expression of the four different crater domains (outer and inner wall, rim and floor) from a very fresh pristine crater. At this purpose we have chosen Linné crater, that is considered one of the best examples of pristine craters on the Moon [3].
The floor presents a mean slope gradient of 0°-3° with a profile curvature of 0.05°; those values are typical of a flat floor. The inner scarp has a mean slope gradient of 31.8°, consistently with the lunar regolith angle of repose (31°), whereas the mean profile curvature is 0.1°, suggesting a slightly convex morphology (> 0).
The most interesting result derives from the rim sector that presents a mean profile curvature of 0.5° (convex morphology), with a slim top area with about 0° of profile curvature and 0° of slope, revealing the presence of a pristine crest: this kind of features are typical of a very fresh crater.

On the outer scarp the mean slope gradient is about 10° and the profile curvature is negative (-0.05°), defining a slightly concave morphology.
Using Linné crater as a morphometric reference for the simple impact crater morphology we have conducted a morphometric analysis on the other three degradation classes (C2, C3, C4), in order to set up the characteristic thresholds of the four degradation classes. Afterwards we applied morphometric analysis on several simple craters on S28 geological unit within mare Serenitatis [2].

2. Morphometric comparison of the four degradation classes

Our results have provided a quantitative distinction among different crater classes and have shown common trends of degradation, going from larger to smaller craters within each class. Morphometric variables allowed the characterization of the morphometric signature of a very fresh impact crater. The resulting distribution of inner walls slope values shows a degradation trend within the first three. The first three degradation classes indeed follow a comparable power law trend: the mean slope increases from small to large diameters, as shown in the inner wall mean slope/diameter ratio diagram (Fig.6). C4 class is instead characterized by a wide dispersion of the data. The distribution of the negative profile curvature values follows a similar power law trend for C1 and C2, which becomes less defined for C3 and disappear in C4. This enlightens how the concavity along the inner wall tends to decrease in function of degradation class from C1 to C4, according with a flattening morphological evolution from less degraded to more degraded craters.
To improve the statistical significance, we have considered also the rim crater sector. We extracted the profile curvatures from craters rim in order to understand the morphological evolution of this feature. We found that the morphological degradation trend of rim and inner wall is comparable so we were able to plot in a 3D diagram rim and inner wall in function to diameter.
The resulting distribution shown a well clustered distribution of the four degradation classes, allowing us to consider it as an objective distinction of the degradation classes (fig 2).

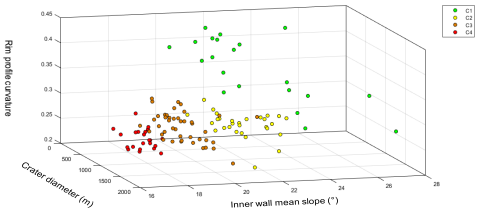

Figure 2: 3D plot of rim profile curvature, inner wall mean slope and diameter.

3. Summary and Conclusions

In this research we have applied morphometric analysis on high resolution topographic data in order to quantify the degradation of simple impact craters. The statistical distribution of the inner wall mean slopes highlighted a similar power law trend of the first three degradation classes, which seems independent from the degradation class. The development of morphometric variables classification described in this research, may be also useful for semi-automatic detection and characterization of the degradation classes of simple craters, potentially helpful for geological mapping and age determination of planetary surfaces.

Acknowledgements

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References

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