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Analysis and global mapping of statistical parameters of Mercury relief characteristics

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Abstract

Our work focuses on calculation of statistical parameters of relief characteristics for the whole Mercury surface, based on the newest DEMs. Also we concentrate on automation of geomorphological classification and mapping.

1. Introduction

The MESSENGER mission in 2011-2015 gives us an opportunity to gain new knowledge about Mercury which is still the least explored planet of the terrestrial group. The study of the relief characteristics by thematic mapping helps to identify common patterns in planetary relief and reveal hidden details. Calculations of Mercury statistical parameters were performed before according to the laser altimetry obtained by MESSENGER [1]. Because of the large eccentricity of the orbit, the altimeter provided measurements only for the northern hemisphere of the planet. Now our possibilities have expanded, because we are analyzing and mapping Mercury surface by new global and local DEMs.

2. Data and Methods

In our work for morphometric calculations we use the newest high resolution DEMs obtained based on photogrammetric processing of MESSENGER stereo images:

- the first global Mercury DEM with the resolution 665 m/pixel [2];

- DEMs on Mercury quadrangles with resolution ~222 m/pixel [3].

Depending on the tasks, the statistical parameters of planetary relief are calculated in different ways. For the purposes of our study we mostly use two techniques:

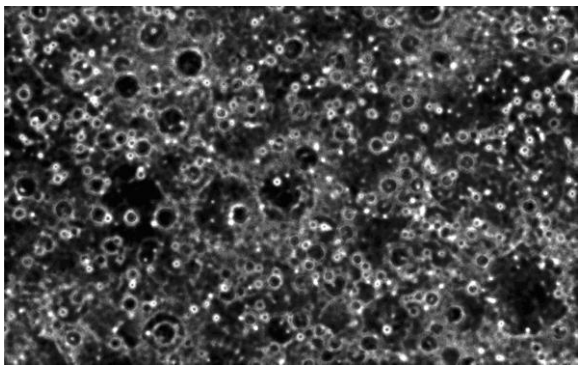
- Interquartile range of the second derivative of heights. For this method we use a previously developed tool integrated into the ArcGIS software [4]. Interquartile range gives the average notion about planetary relief, but at the same time it points to geological age of some features and shows old hidden structures that are not visible on images.

- Relative topographic position (RTP). For this method topographic position of each pixel is identified with respect to its local neighborhood [5]. Results of calculations are useful for identifying types of landscapes, prevailing geomorphological processes and defining boundaries of surface types.

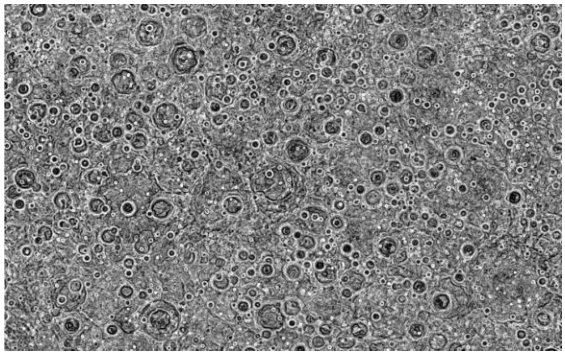
3. Main results

Using the global DEM with resolution of 665 m/pixel we have preliminarily calculated the statistical characteristics of entire Mercury by interquartile range method [6]. Then the relative topographic position was calculated.

For testing the automated geomorphologic zoning by calculations and classification of statistical parameters, the DEM of the site H-6 (Kuiper) was selected (Fig. 1 a,b).



a) Topographic roughness (on the basis of 32 km)



b) Relative topographic position (calculated in a 30-pixel window)

Figure 1: Calculations of statistical parameters of H-6 quadrangle (Kuiper) of Mercury based on detailed DEM (222 m/pixel): dark areas – smooth surface, bright – rough.

We used method of interquartile range of the second derivative of heights to find boundary values between different forms of macrorelief.

Figure 2 below shows an example of preliminary automated geomorphologic classification based on computed topographic roughness. We aimed to achieve high coherence between our suggested values of roughness for smooth plains and previously known boundaries of this type of Mercury relief form [7]. Obtained results showed good agreement.

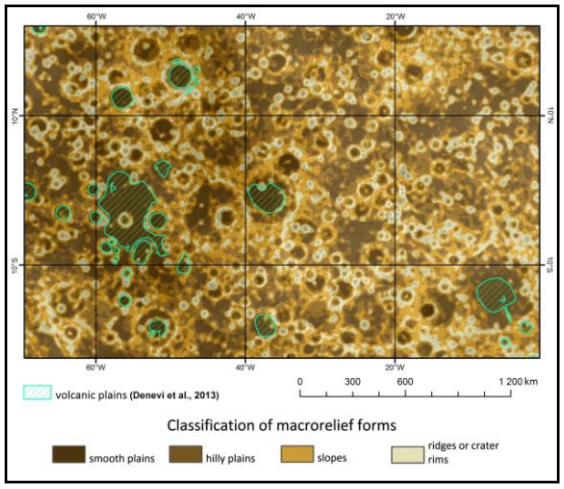


Figure 2: Trial classification of relief forms based on roughness values on H-6 quadrangle (Kuiper), green shaded areas correspond to the volcanic plains [12]

4. Verification of zoning

We used morphometric measurements of small craters (less than 1 kilometer in diameter) for additional verification of zoning results, because distribution of such craters depends on the type of surface.

Our analysis of about 1400 images, received by MESSENGER narrow-angle camera, showed that small craters with flat floors are mostly confined to Mercury's smooth plains (Table 1).

Table 1: Number and percentage of images with flat-floored craters within and outside geologically young smooth plains

	Images surveyed	Of them, with flat floored craters	Percentage
Within smooth plains	641	202	31.5%
Outside smooth plains	768	113	14.7%
Total	1409	315	22.4%

5. Summary and Conclusions

We are working on creation of the first global morphological map of Mercury, for which an automated classification of relief forms will be developed.

In the future, we plan to use the relative topographic position method more deeply. We hope that the combination of different methods will give us the opportunity to create the most complete classification of Mercury relief forms.

Such results can be used to process the data of the future European mission BepiColombo (2018).

Acknowledgements

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