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Mapping of photometric anomaly of Martian surface with HRSC data

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Photometric properties, the dependence of the surface brightness on the geometry of illumination and observation, bear information about structure of the surface in a wide range of scales. Mapping of photometric properties gives a new dimension and complimentary information for characterization and classification of surfaces and understanding surface processes.

Five panchromatic channels of the HRSC camera give principal possibility to obtain photometric information, although the range of angles is too small for complete photometric characterization. The extraction of photometric information is hindered by the effects of the atmosphere, which is variable and unknown. We propose a method to solve these problems. We assume that the atmosphere is the same for the whole image, and that the apparent brightness variations due to variations of the surface albedo are much greater than apparent brightness variations due to variations of the photometric properties. Our method implicitly uses the dark and bright areas to learn something about the atmosphere and eliminate its effect. The outcome of our procedure is a single parameter of photometric anomaly.

We start with the calibrated map-projected images in five panchromatic channels; we split long images in 2-3 parts. We add antiquantization noise to suppress harmful visual effects of lossy compression, reduce image resolution down to 8x8 macropixel, perform accurate coregistration of all five channels, and divide reflectance in each

channel by cosine of local incidence angle. Then we choose an analysis area, which is large, horizontal, and contains high albedo variations; we exclude geometric shadows, small features and local sharp contrasts. Than we perform the principal component analysis using the analysis area for calculation of the correlation matrix. We assume that the first principal component contains variations of albedo and variations of the photometric function that correlates with albedo. We calculate a parameter of photometric anomaly as such linear combination of the other four principal components that has the highest correlation with the phase angle. This parameter depends on the surface photometric function only.

The maps of the photometric anomaly obtained in this way contain interesting and interpretable features. For example, small craters in Gusev floor have anomalously gentle phase function due to lack of rock fragments, as it is seen in Spirit panoramas. The anomaly maps help distinguish depositional and deflational wind streaks: the latter have more rock fragments and steeper phase function; etc. The photometric anomaly maps also reveal thin haze structures and compact dust clouds not apparent in the images.

Our method has the following shortcomings: (1) the photometric anomaly is arbitrary normalized; (2) as a result, anomaly in different images can be compared only qualitatively; (3) the anomaly parameter is meaningful for horizontal surfaces only; (4) the method is not applicable for images without wide albedo variations; (5) it is not applicable for data sets where the phase angle difference between channels is small; (6) if the scene has large elevation variations, the difference in atmospheric thickness can distort the results; (7) the results depend on subjective choice of the analysis area (although practically this dependence is not essential). The method has a number of strong advantages: (1) it relies on the HRSC data only and is free from any model assumptions; (2) it is absolutely tolerant to imperfections of photometric calibrations; (3) it is rather tolerant to imperfections of the flat fields; (4) the data processing can be automated for routine processing of the HRSC data sets.