Reduction of illumination-induced topographic shading effects on HRSC image mosaics of Mars S. H. G. Walter (1) (s.walter@fu-berlin.de), G. G. Michael (1), K. Gwinner (2), R. Jaumann (2); (1) Institute for Geological Sciences, Freie Universität Berlin, Berlin, Germany; (2) Institute of Planetary Research, German Aerospace Center (DLR), Berlin, Germany

Introduction: Current efforts for image mosaics from the High Resolution Stereo Camera (HRSC, [1]) on board Mars Express are ongoing [2, 3]. Usually, illumination effects between adjacent single images related to the planetary curvature are reduced by using a *Lambert* correction and subsequent normalization to a common brightness reference. Here we present an additional correction of topography-induced shading effects by using the illumination angles with reference to the local topography represented by the digital terrain model (DTM) associated to every single HRSC scene, resulting in top-of-the-atmosphere albedo images of the surface.

Scattering models: When used for illumination corrections taking the local topography into account, the *Lambertian* model and its associated *cosine correction* tends to over-correct on large incidence angles (under-illuminated pixels), as observed on crater slopes at low Sun angles. Therefore we do not consider it for our work but use it as a reference for comparison reasons (see Fig. 1 top – the saturation level of one is reached at around 70° effective incidence angle).

The one-parameter model by *Minnaert* [4] is known for its good reproduction of the Martian surface. Depending on its parameter k, the saturation effect of the correction appears at higher incidence angles and is therefore better suited for topographic corrections. Still, in the case of HRSC, the Sun incidence angle on the ellipsoid is often higher than 60° and adding the slope angles results in incidence angles higher than 80°. This leads to very bright over-corrected pixels in highly inclined areas facing away from the Sun (see Fig. 1 middle – depending on the k parameter, the saturation level is reached at around 80° incidence angle). The k parameter can be modeled using a non-linear least square minimization for every HRSC scene assuming one constant parameter over all pixels of the whole image.

The correction used by *Teillet* et al. [5] is well suited for topographic corrections due to its minimal amount of overcorrection (cf. Fig. 1 for plots of varying parameter settings and 2 for the result). The single parameter is derived by a relation of the incidence on the ellipsoid to the mean incidince with regards to the topography.

Results: We corrected a common set of HRSC images using the three mentioned scattering models and assembled a respective mosaic for each by applying the methods from [2] (see Fig. 2). The results for the Minnaert and the Teillet model appeared very consistent in a visual inspection. Due to the high slope angles often appearing in HRSC scenes, the Minnaert model sometimes results in saturated pixels, while the Teillet model achieves more modest levels of correction. We have not observed any advantage of the Minnaert model over the Teillet model, although it additionally includes emission angle values in the model. This lets us assume that the emission angles have a minor effect on the topography-induced illumination effects.

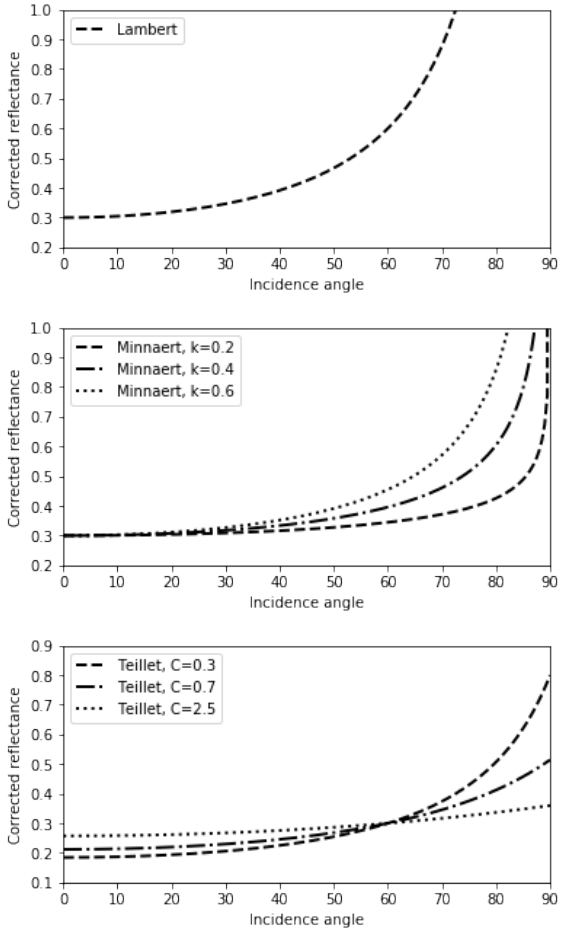

Figure 1: Correction curves using different photometric functions; top: Lambert model; middle: Minnaert model, emission angle=0°; bottom: Teillet model, incidence on ellipsoid=60°. A reflectance of 0.3 is assumed for all plots.

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References: [1] R. Jaumann et al., *PSS* 55.7 (2007), DOI: 10.1016/j.pss.2006.12.003. [2] G. G. Michael et al., PSS (2016), DOI: 10.1016/j.pss.2015.12.002. [3] G. G. Michael et al., *4th planetdata*, 2019, #7058. [4] M. Minnaert, ApJ 93 (1941), 403–410, DOI: 10.1086/144279. [5] P.M. Teillet et al., *CJRS* 8.2 (1982), DOI: 10.1080/07038992.1982.10855028.

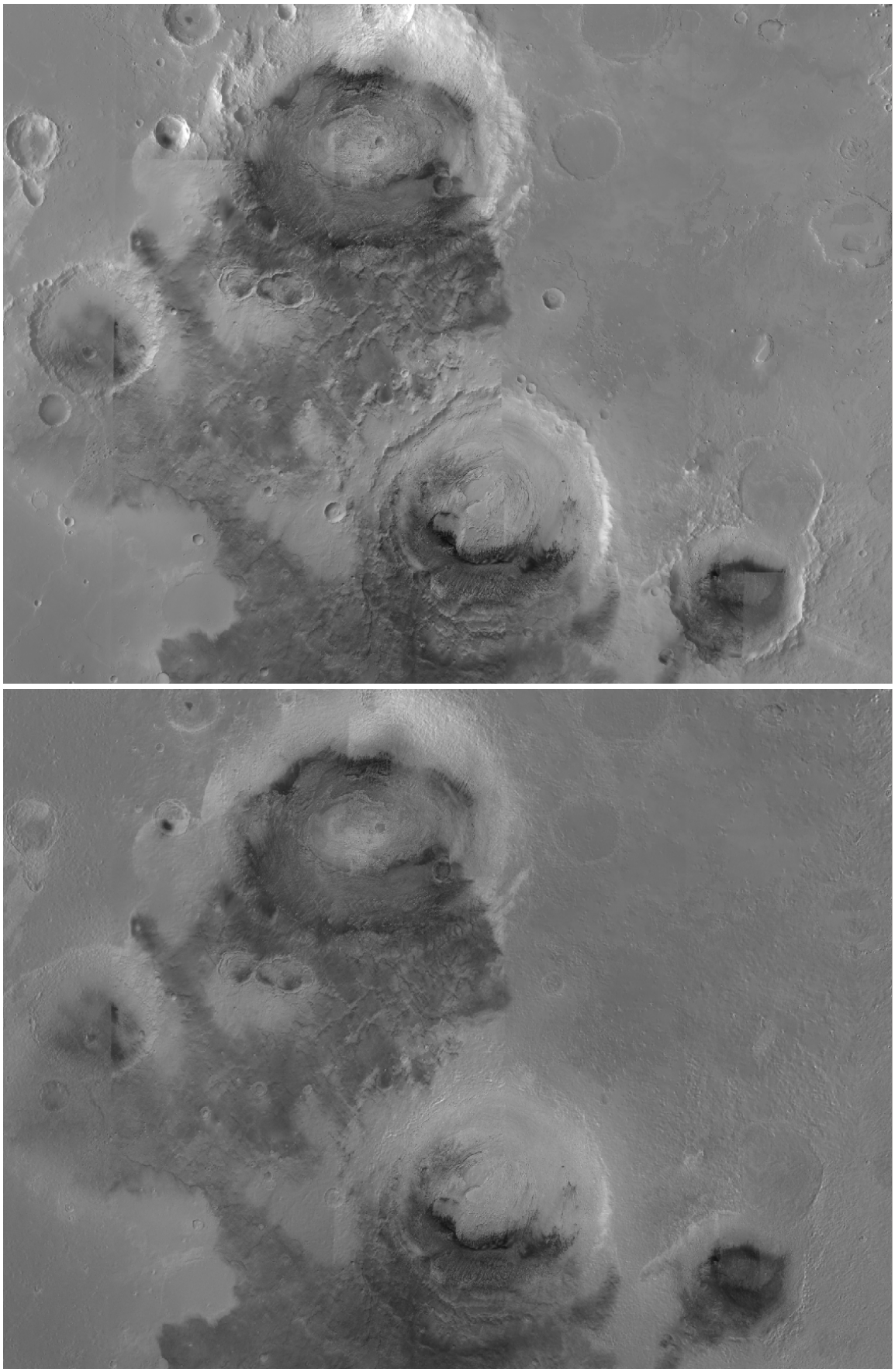

Figure 2: Subset of the image mosaics; top: uncorrected image mosaic as shown in [2]; bottom: image mosaic with removed shading using the Teillet scattering model.