Computational Models for Mercury Surface Analysis

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Computational Models help Us to understand the surface of Mercury.

Shape from shading with Bepi's MCAM

On the 1st of October 2021, BepiColombo performed its first swing-by maneuver with Mercury, and the three monitoring cameras (MCAMs) captured parts of the surface [Fig. 1]. We generate a DEM of a region northwest of Sihtu Planitia and find that MCAM images are sufficient to refine the global stereo DEM of [1]. We demonstrate the performance of Shape-from Shading under challenging conditions of a planetary flyby.

First, we co-register and map the visible part of image CAM2_2021-274T234412_6 [Fig. 2]. Second, we calibrate the MCAM image to reflectance values. Therefore, we estimate a simple calibration curve from the pixel intensities and a synthetic reflectance map of the region derived from Hapke modeling. Third, we apply Shape-and-Albedo-from-Shading [2,3] and generate a detailed DEM of Mercury's surface [Fig. 3]. Further, we evaluate the algorithm's performance for several extreme cases.

Fig. 1: BepiColombo MCAM 2 image

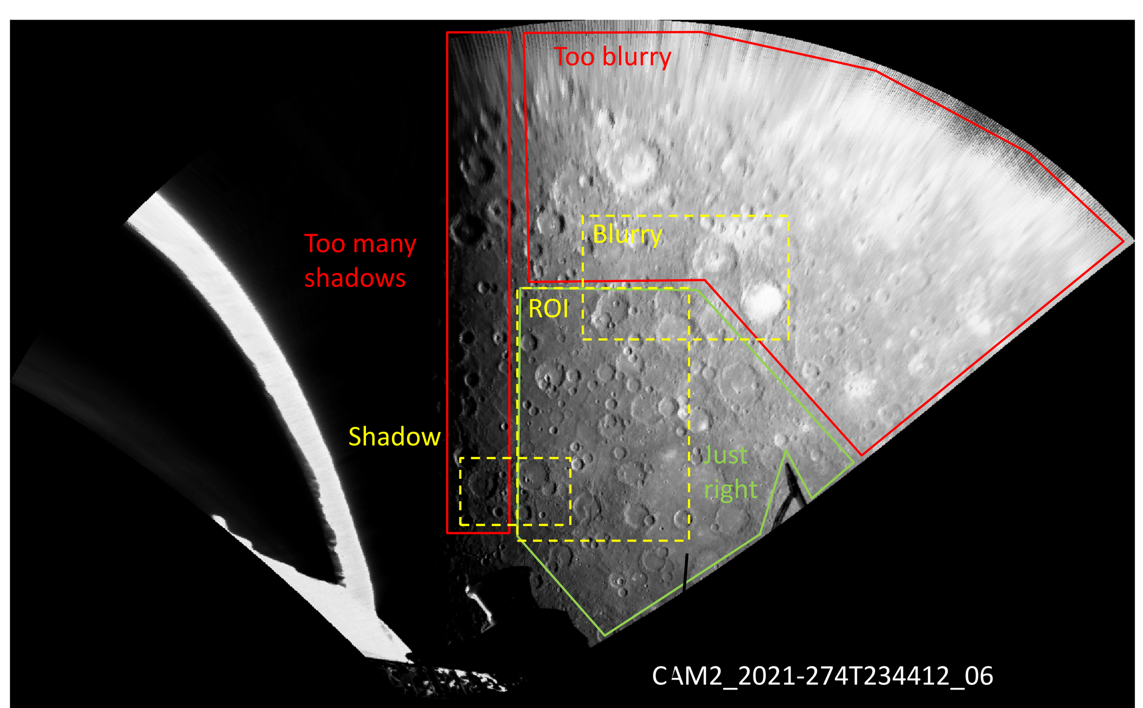

Fig. 2: Co-registered and projected image

Figure 3 shows the final product of a region northwest of Sihtu Planitia. The DEM provides more details compared to the global stereo DEM of Mercury [Fig. 4 vs. Fig. 5]. With high-resolution images from MESSENGER and BepiColombo, Shape from shading can be used to refine tectonic features, volcanic features, and hollows [3].

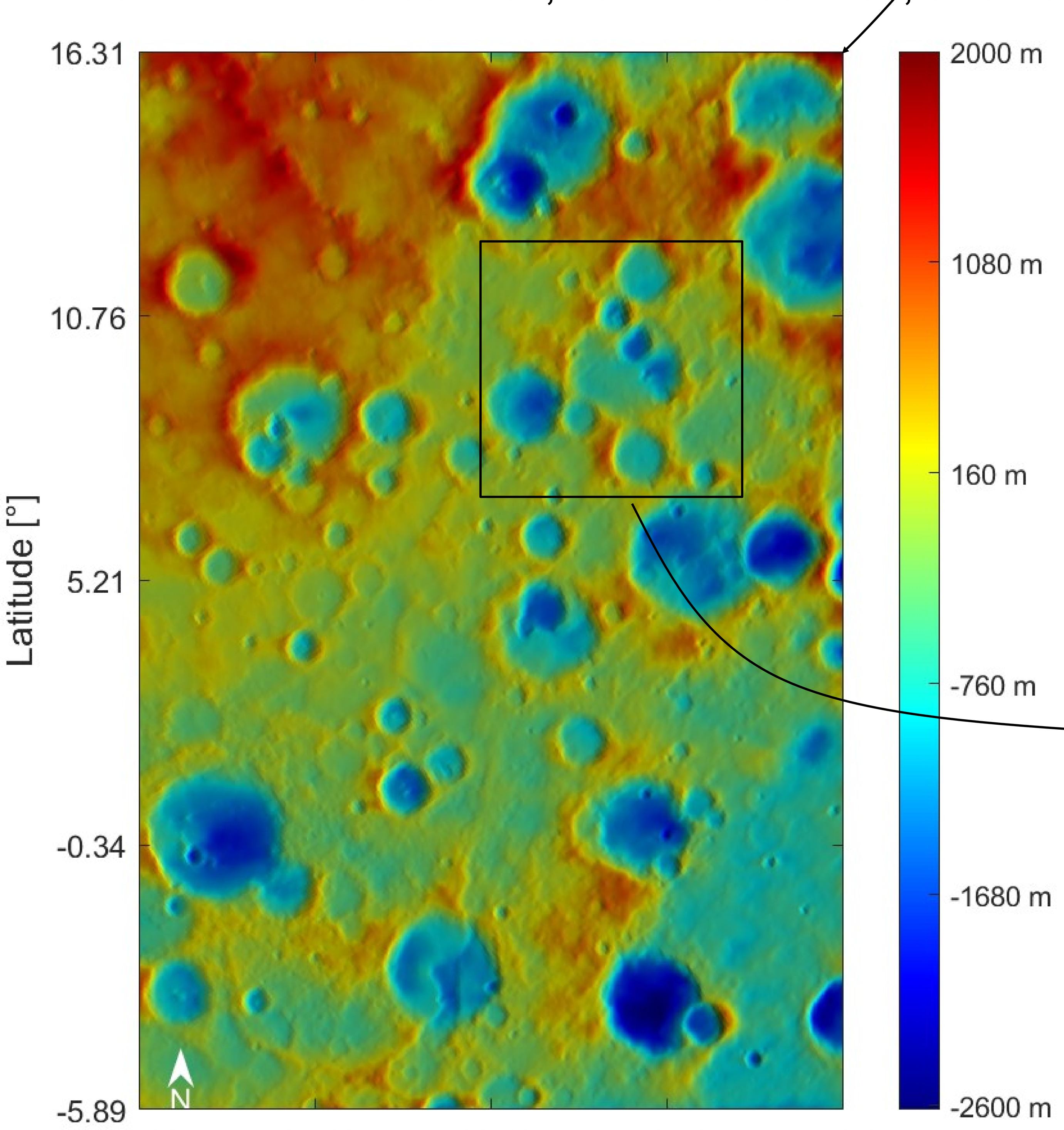

Fig. 3: Shape-from-shading result from MCAM images. The region corresponds to the ROI in Figure 2.

BEFORE

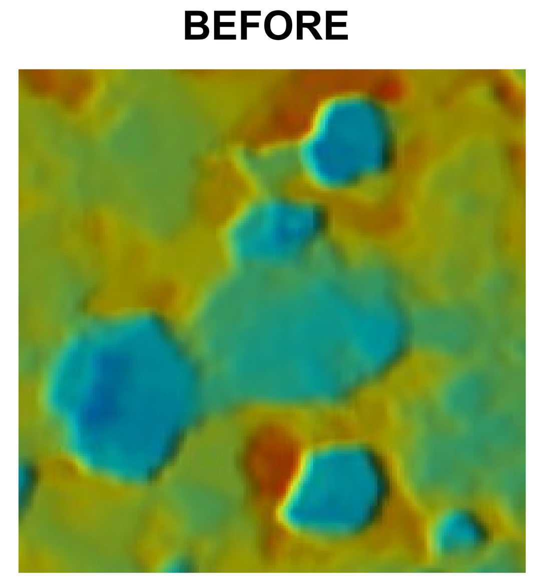

Fig. 4: Outcrop of global stereo DEM [1]. Some features are not visible and the crater rims are unnaturally jagged.

AFTER

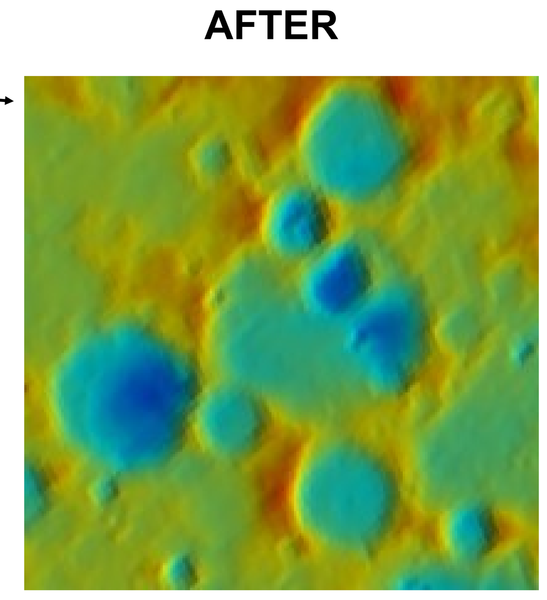

Fig. 5: More details become visible. Note the chain of four craters in the center.

→ Check out the results from the second Mercury flyby: https://www.youtube.com/watch?v=jLyj2G7HFrg

Thermal modeling for Bepi's MERTIS

The Mercury Radiometer and Thermal Infrared Spectrometer (MERTIS) is planned to acquire infrared spectra of Mercury from 7-14 µm [4]. The emissivity has to be extracted from radiance measurements for mineralogical analysis, which requires a thermal roughness model.

→ Here, we apply our thermal roughness model [5] to MERTIS lunar flyby measurements. It extends upon [6,7]. We prepare it for upcoming Mercury radiance spectra acquired by MERTIS in the future.

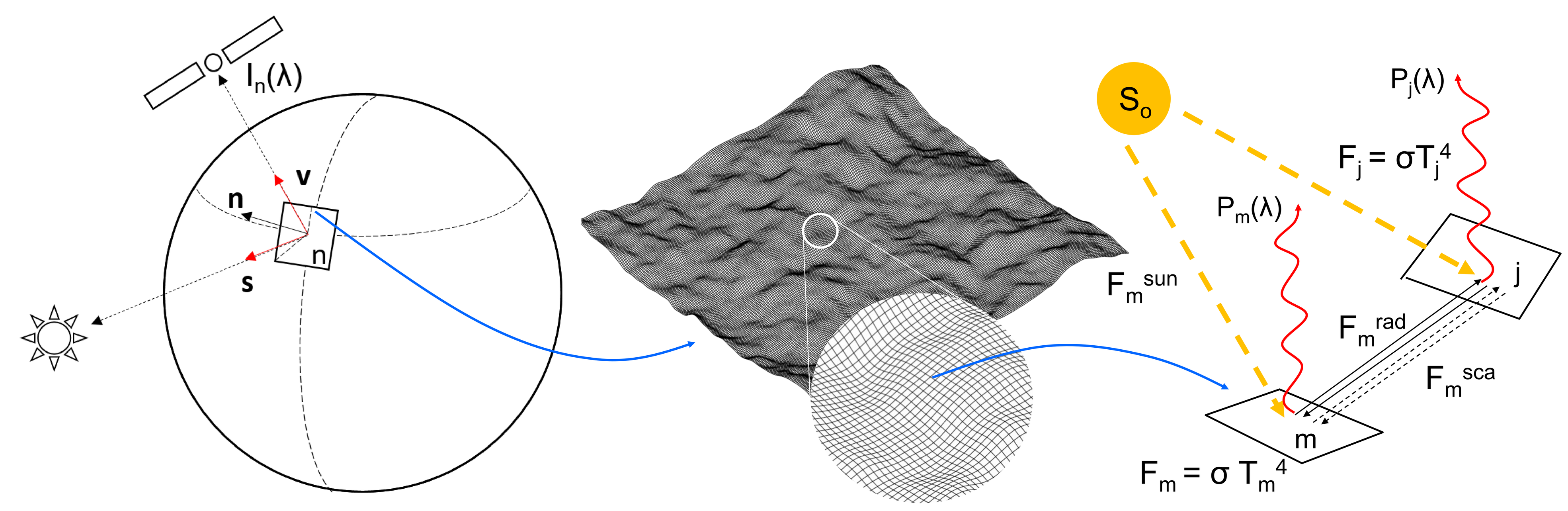

Fig. 6: Left: The entire planet is divided into facets with individual illumination conditions.
Middle: 40,000 pixels constitute a fractal rough surface constrained by [8].
Right: Our model considers shadowing, self-scattering and self-heating and outputs the thermal radiation.

On April 9th, 2020, BepiColombo performed a swing-by maneuver with Earth, and MERTIS acquired the first space-borne lunar spectra in the thermal infrared [9]. In total, seven of one-hundred pixels of the push-broom-sensor scanned the Moon. For model validation, we compared our thermal model with the flyby data. Because the Moon is well known and the thermal model is already validated on the Moon, this step is the first test of MERTIS's capabilities in space. As shown in Figure 9, our model accurately captures the thermal roughness effects of the Moon.

Fig. 7: Left: The Earth and the Moon seen by BepiColombo's MCAM, Right: Image of the Earth with clouds.

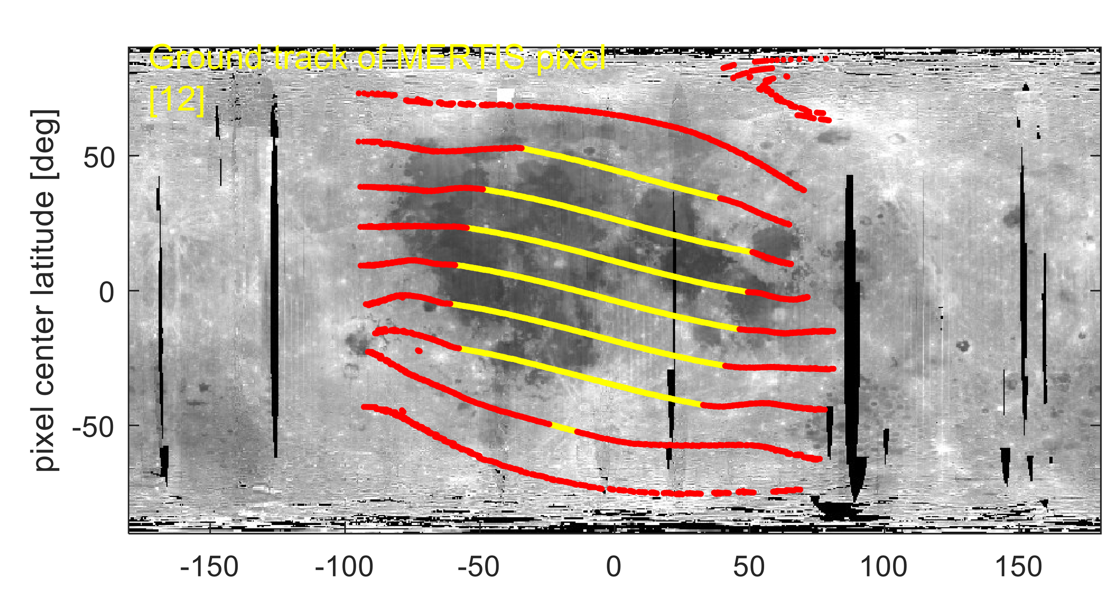

Fig. 8: Footprint of MERTIS pixels on the Moon.

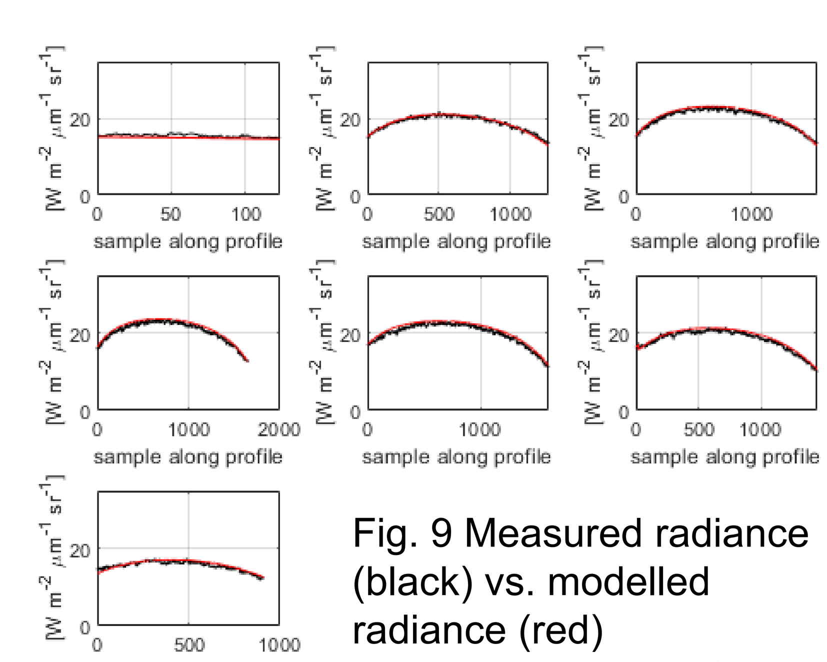

Fig. 9 Measured radiance (black) vs. modelled radiance (red) at 10.95 µm. Taken from [5,10].

→ Our model matches the data!

References

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