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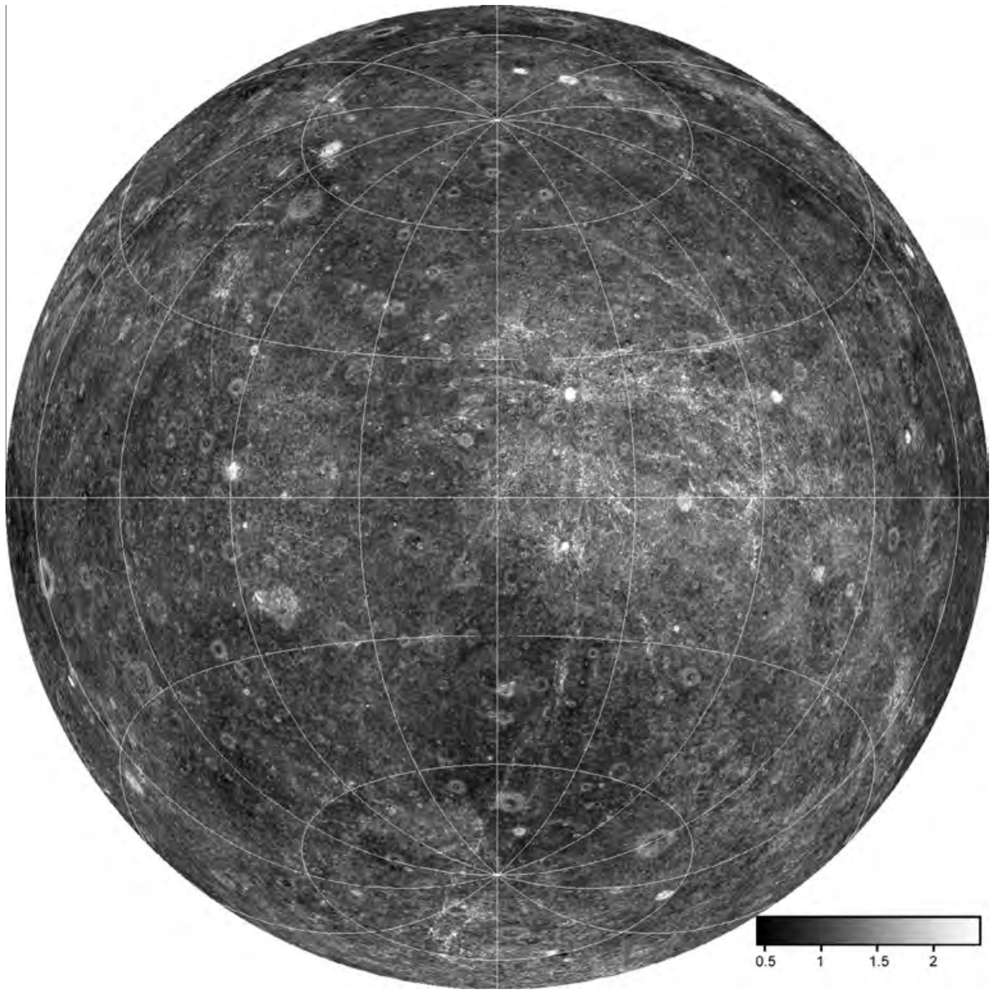

Fig. 3. Map of hectometer-scale roughness of the Moon (115 m baseline). Lambert azimuthal equal-area projection centered at the center of the farside. Latitude/longitude grid is 30° × 30°. Brighter shades denote rougher surfaces. Dimensionless absolute roughness values are defined according to Eq. (2).

and requirement (6) dictates that different measures are used with different data sets.

Requirements for a "good" measure of roughness are often contradictory, and the choice involves multiple trade-offs. In the case of LOLA data, the high regularity and precision along the orbit tracks and lower precision and irregular gaps between the orbits suggest the use of along-track statistics for characterization of the surface topography. Since all LRO orbit tracks are in the north–south direction, this means that the measure of roughness used is anisotropic, which is not consistent with our intuitive perception of "roughness". The spurious effect of the anisotropic roughness measure is noticeable, for example, on walls of large (resolved) craters in the longer-baseline maps: the northern and southern walls of the craters are rougher than the western and eastern walls. Topographic data derived from stereo images (e.g., Scholten et al., 2012) are (almost) free from such inherent anisotropy; their use for roughness mapping, however, is limited due to the lower vertical precision in comparison to LOLA. The "full" LOLA shots with good range measurements for all five spots could give a much more isotropic roughness measure, but only for a single baseline of ~50 m. Since we aimed to study the scale-dependence of roughness and wanted the same roughness measure at different baselines, we restricted ourselves to bare one-spot along-track profiles.

To meet requirement (2) we followed Kreslavsky and Head (2002) and chose to use the second derivative ("curvature") of topographic profiles. Another possibility to meet requirement (2) is the differential slope used by Kreslavsky and Head (2000) and Rosenburg et al. (2011). The use of the differential slope instead of the "curvature" yields very similar-looking maps. Calculation of the "curvature" requires at least three data points (Eq. (1)), while calculation of the differential slope requires at least four; because of this, the "curvature" can be a little more tolerant of missing and bad measurements and this is why we prefer to use it here. A popular alternative way to fit requirement (2) is to use slopes (the first derivative) after some detrending procedure that removes large-scale tilts. We preferred not to use this approach because this method gives a worse scale separation (requirement 4) and introduces new subjectivity in the choice of the detrending scale and procedure. The shortcoming of our choice is that the numerical values of our roughness measure are not intuitive.

Calculation of the second derivative at a given baseline is actually an application of some linear filter: a sequence of discrete points representing a profile is convolved with some kernel. This kernel can be chosen in different ways. We chose the minimal kernel defined by Eq. (1): it contains the fewest possible number of points (three) and has the shortest possible support range for a given baseline. The former gives us the best tolerance to missing and bad points (requirement 6); the latter enhances the visual sharpness (requirement 8). The minimal kernel, however, is far from optimal from other points of view: including more points in the kernel would reduce noise (especially, for long baselines) (requirement 7) and