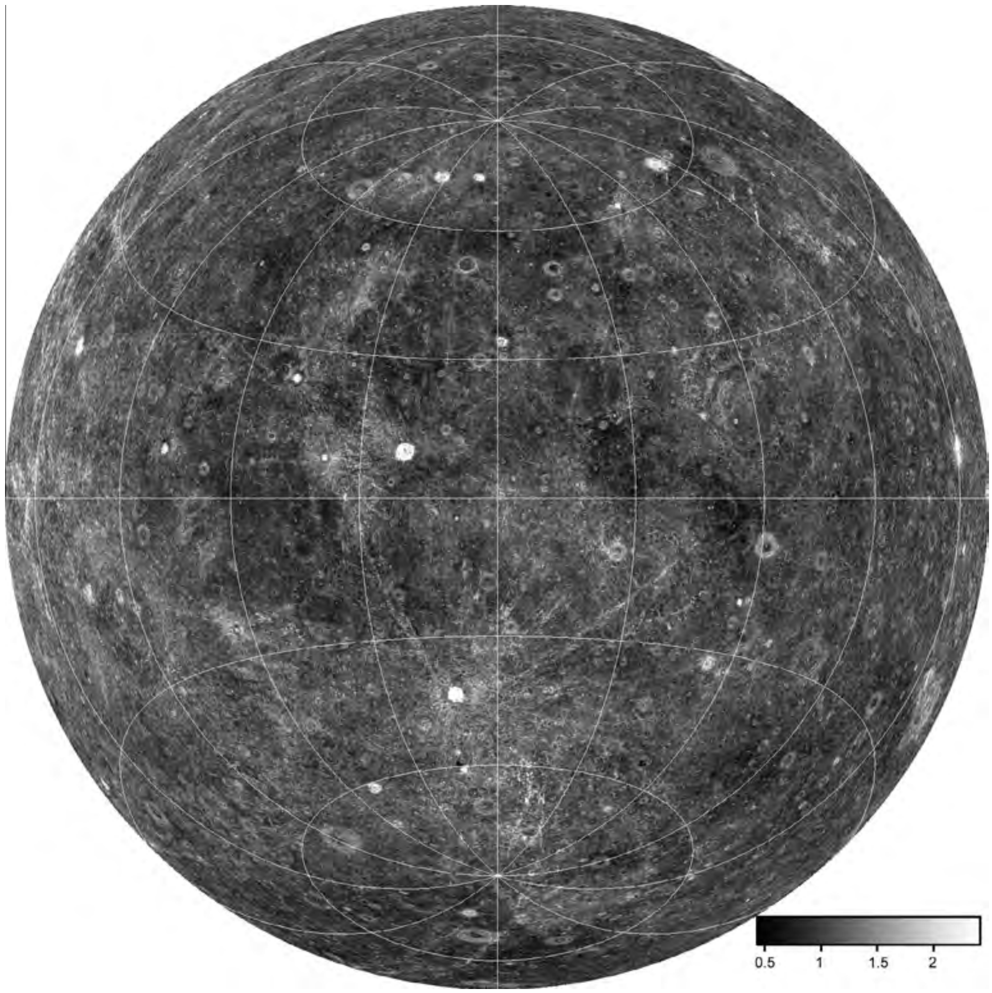

Fig. 2. Map of hectometer-scale roughness of the Moon (115 m baseline). Lambert azimuthal equal-area projection centered at the center of the nearside. Latitude/longitude grid is 30° × 30°. Brighter shades denote rougher surfaces. Dimensionless absolute roughness values are defined according to Eq. (2).

et al., 2011 and references therein), a dimensionless number between $0 \leqslant H \leqslant 1$. Warm (reddish) tints in the maps (Figs. 4 and 5) mean relatively higher intensity in the red channel and the prevalence of large-scale roughness, which means higher H. Analogously, cold (bluish) tints mean the prevalence of small-scale roughness and lower H. Color variations are subtle because the range of baselines used is rather narrow.

2.3. Rationale for the data processing algorithm

Our experience shows that the success of geological interpretation of roughness maps strongly depends on a good choice of roughness measure and an optimal choice of mapping technology. A good statistical measure of roughness should possess the following properties. (1) It should correspond to an intuitive perception of "roughness": if, in an image taken at the proper resolution, geological unit A looks distinctively rougher than unit B, then the roughness map at the proper baseline should reflect this difference. (2) The tilt of the surface as a whole should not change roughness values. For example, the variance of elevation at a given baseline is not a good measure of roughness, because it is sensitive to regional slopes. (3) Roughness should characterize a typical surface rather than its prominent features (as discussed in Section 1). For example, the RMS slope at a given baseline, a popular statistic of topography, is not a good measure of roughness, because it is very sensitive to the presence of a small proportion of very steep slopes in the sample; for the Moon, RMS slope would primarily reflect steep features (for example, crater walls). (4) Roughness should characterize topography at a well-defined scale, because the nature of its scale-dependence is an important characteristic of geological surfaces. (5) The statistical measure of roughness should be stable: if there is a homogeneous geological unit, its roughness calculated over a large data set and over a small (but representative) subset of the same data should be similar. For example, RMS slope is often not stable: natural surfaces often have heavy tails of slope–frequency distributions, and the occurrence of rare very steep slopes offset the RMS slope significantly. For many natural terrains the tails of the slope–frequency distribution are so heavy that the RMS slope calculated over a smaller data subset is systematically lower than that calculated over the whole data set. (6) The selected measure of roughness should be tolerant to individual peculiarities of the source data set used. Mapping of roughness (rather than just characterizing different areas) adds two more requirements. (7) Low noise (which is partly, but not exactly, the same as the stability requirement above). (8) Visual sharpness of resulting maps. Our experience shows that the latter is extremely important for successful geological interpretation of the maps.

From this "definition", it is clear that there is no universally good measure of topographic roughness. First, "intuitive perception of roughness" in requirement (1) is quite subjective, and different researchers may have different personal preferences. Second, different data sets have individual problems and peculiarities,