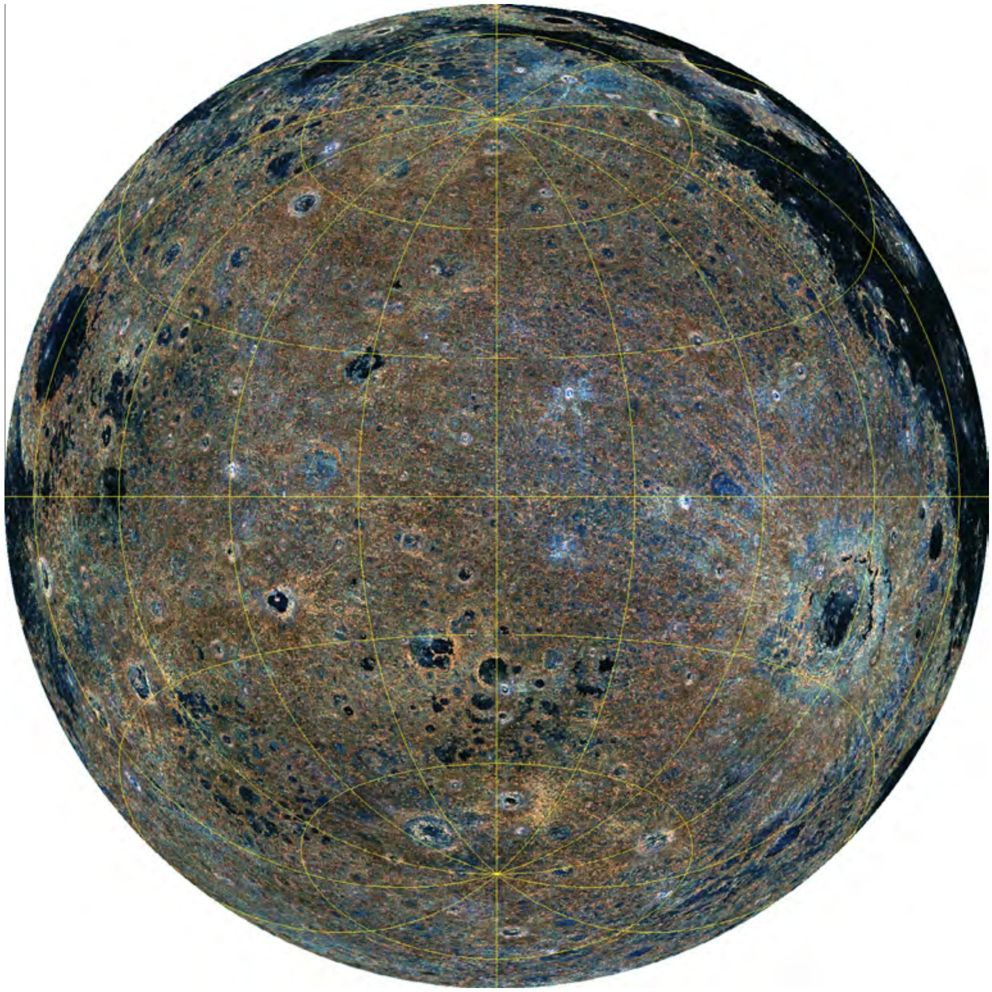

Fig. 5. Kilometer-scale roughness of the Moon rendered as an RGB composite of roughness maps at 1.8 km, 0.96 km, and 0.48 km for red, green, and blue channels, respectively; higher intensity in each channel denotes higher roughness. Lambert azimuthal equal-area projections centered at the center of the farside. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

ness are within the range of 0.9–1.1, and that of maria are within the range of 0.4–0.5; in other words, the systematic difference between maria and highlands (a factor of 2) is much greater than the typical roughness variations over maria and over highlands (~20% in both cases). For longer baselines the systematic difference between maria and highlands increases and reaches a factor of 10 at 1.8 km baseline. At this baseline, typical short-range variations of highland roughness are significant (a factor of 3) due to an effective noise increase when the baseline becomes comparable to R_{pix}. However, typical values over larger areas vary within 30% for both maria and highlands and are minuscule in comparison to the systematic difference between maria and highlands.

The maps of hectometer-scale roughness (115 m baseline, Figs. 2 and 3) look strikingly different, despite the fact that the baselines differ only by two octaves (a factor of four) from 0.48 km. At the hectometer scale, there is no significant difference between maria and highlands. In many locations the mare/highland boundary is not associated with any roughness contrast. All typical roughness contrasts are minor (within 40%, compare gray scales in Figs. 1 and 2), except that of young craters (Section 4.1). Although lowered roughness values tend to be associated with maria, some mare surfaces are rougher than typical highlands, for example, the central part of Mare Crisium has $r \approx 1.1$.

We interpret this striking difference to be due to the principal difference in the processes that shape the surface at hectometer and kilometer scales. The hectometer scale is dominated by formation of small (hectometer-scale and smaller) craters and regolith gardening by even smaller impacts. Fig. 7 illustrates that the difference between typical mare and highland surfaces, considered at the resolution relevant to the hectometer-scale roughness, is not very strong. These LRO Lunar Reconnaissance Orbiter Camera (LROC) images were specially selected to minimize the difference between illumination conditions, so that their direct comparison is most useful.

The typical values of dimensional roughness, $r_0 \approx 2 \times 10^{-4}\ \mathrm{m}^{-1}$ at l = 115 m baseline correspond to a characteristic vertical scale of $r_0 l^2 \approx 3$ m, less than a typical regolith thickness. This is consistent with regolith processes being solely responsible for the roughness signatures at the hectometer scales. Both on maria and highlands the population of hectometer and smaller craters is in an equilibrium state, when ongoing emplacement of small craters is balanced by ongoing obliteration of old craters by regolith gardening. Progressively degrading hectometer-scale craters form the background topography in a similar manner on the mare and highland surfaces.

Formation of larger, kilometer-scale craters is not equilibrated with crater obliteration, and there is no uniform equilibrated background topography at such scales. At the longest baseline, l = 1.8 km, the characteristic vertical scale, $r_0 l^2 \approx 90$ m, is greater than the typical regolith thickness. This means that regolith