The surface roughness of asteroid 25143 Itokawa and 433 Eros. Olivier S. Barnouin-Jha,[1] Andrew F. Cheng[1,2] and Robert W. Gaskell[3], [1]Johns Hopkins University Applied Physics Laboratory, Laurel, MD 20723 (olivier.barnouin-jha@jhuapl.edu; andy.cheng@jhuapl.edu); [2]NASA Headquarters, Washington D.C., 20546; [3]Planetary Science Institute, Tucson, AZ 85719 (rgaskell@psi.edu).

Introduction: The recent visit of the Hayabusa spacecraft to the small near-Earth asteroid (NEA) 25143 Itokawa yielded the surprising discovery that Itokawa was not an intact object but a low density, gravitationally accumulated, rubble pile [1]. This contrasts with the finding, from the only other NEA visited by an asteroid lander, that 433 Eros was an intact object and not a rubble pile [e.g., 2]. Eros was visited by the NEAR Shoemaker spacecraft which landed in 2001. Accurately co-registered, high resolution imager and lidar data from NEAR Shoemaker have demonstrated the fractal properties of small scale surface topography on Eros, where boulders tend to be found on the tops of long ridges, consistent with the presence of an underlying globally coherent structure [3]. However, Itokawa is a rubble pile with a fundamentally different collisional history. Here we analyze co-registered, high resolution laser altimeter and imager data from Itokawa, obtained by Hayabusa, to explore fractal properties and surface roughness distributions on Itokawa for comparison with the results from Eros.

Obtaining meaningful topographic data from the Hayabusa: Estimates of the Hayabusa spacecraft position relative to Itokawa were, upon arrival, insufficiently accurate to generate useful topographic profiles with the Hayabusa laser altimeter (LIDAR). To achieve the objectives of this study, a new algorithm was developed to better locate the spacecraft relative to the asteroid. Housekeeping data were used, combining a LIDAR range every 2min with an x-y pixel measurement obtained by the Wide Angle Camera (WAC) of the illuminated centroid of Itokawa. With the accurately known pointing of the LIDAR and the WAC, and a shape model of Itokawa, we determine the location of the spacecraft and hence the LIDAR footprint to within 10m.

Computing Surface Roughness: The improved LIDAR footprint location enabled a quantitative assessment of variations in surface roughness of Itokawa which can be compared to data for Eros. Roughness is characterized as in [4] using individual LIDAR profiles to determine the standard deviation σ (square root of Allan variance) of height differences versus baseline L. The standard deviation is $\sigma=<[e(s)-e(s+L)]^2>^{0.5}$, where e is elevation along a LIDAR profile at a distance s. The value of e is computed relative to the local geoid, and then detrended to remove the regional slope.

A roughness map of the surface of Itokawa is obtained by performing the above analysis on individual LIDAR profiles within latitudinal and longitudinal bins that are equal in area to within a factor of two, and binning the results. A similar product is currently being generated using the NEAR laser rangefinder data for Eros. More advanced products are being generated, which in some instances will be higher in spatial resolution and will be directly overlain onto shape models of Itokawa and Eros.

Results: A broad comparison of the elevation (Figure 1) and roughness (Figure 2) across the asteroid reveals at nearly any baseline *L* that the highlands are always rougher than the lowlands. Regions lying at intermediate heights typically possess intermediate values of roughness. Such a view is consistent with the idea that mobile regolith fills in and smoothes lowlands [5]. The areas of greatest roughness delineate a ring around the 'head' of Itokawa at 0 E 0N and around the backside of Itokawa near 180E 0N, especially at large *L*. This is where rapid changes in elevation occur, and might be indicative of boundaries to large individual masses or cores that make up the interior of Itokawa. Individual boulders south of the 'head' and the boulder Yoshinodai cause local roughness peaks at large *L*

Also of interest is that the roughness of most areas changes little with increasing baseline. This apparently non-fractal behavior on observed baselines may be related to Itokawa's rubble pile structure and origins.

References: [1] Fujiwara et al., *Science*, 312:1330–1334, 2006. [2] Wilkison et al., *Icarus*,155: 94-103, 2002. [3] Cheng et al., *Science*, 292:488–491, 2001. [4] Shepard, M. K. et al. *Journal of Geophysical Research*, 106:32777–32796, 2001. [5] Cheng et al. *Geophysical Research Letters*, 34, L09201, 2007.

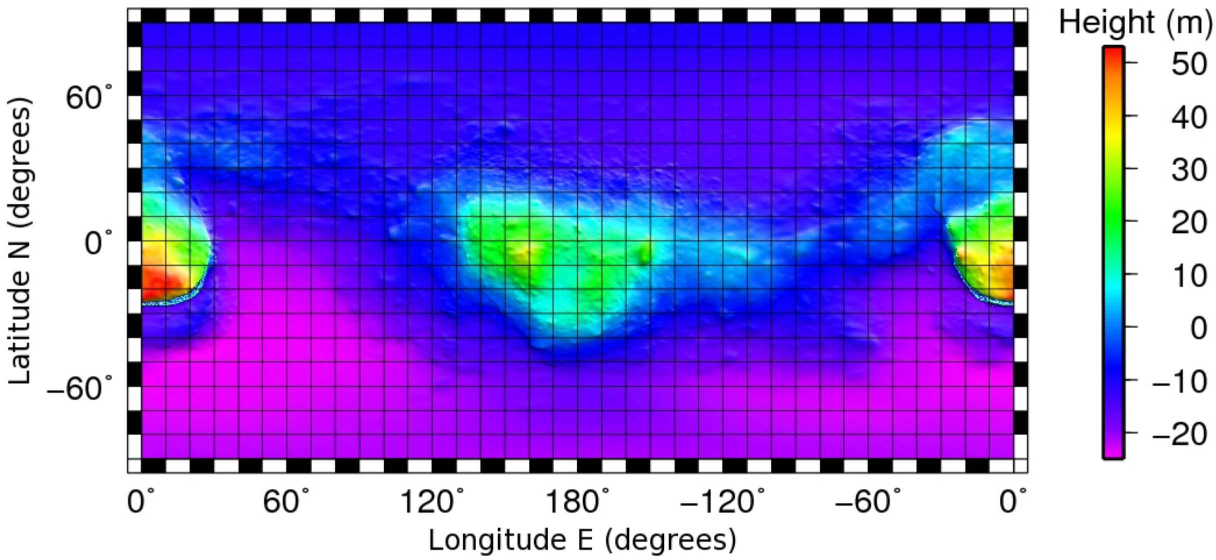

Figure 1. Elevation across the surface of Itokawa. Muses-C Regio is located at -30N 60E and the large boulder Yoshinodai is the high feature near 0N 170E.

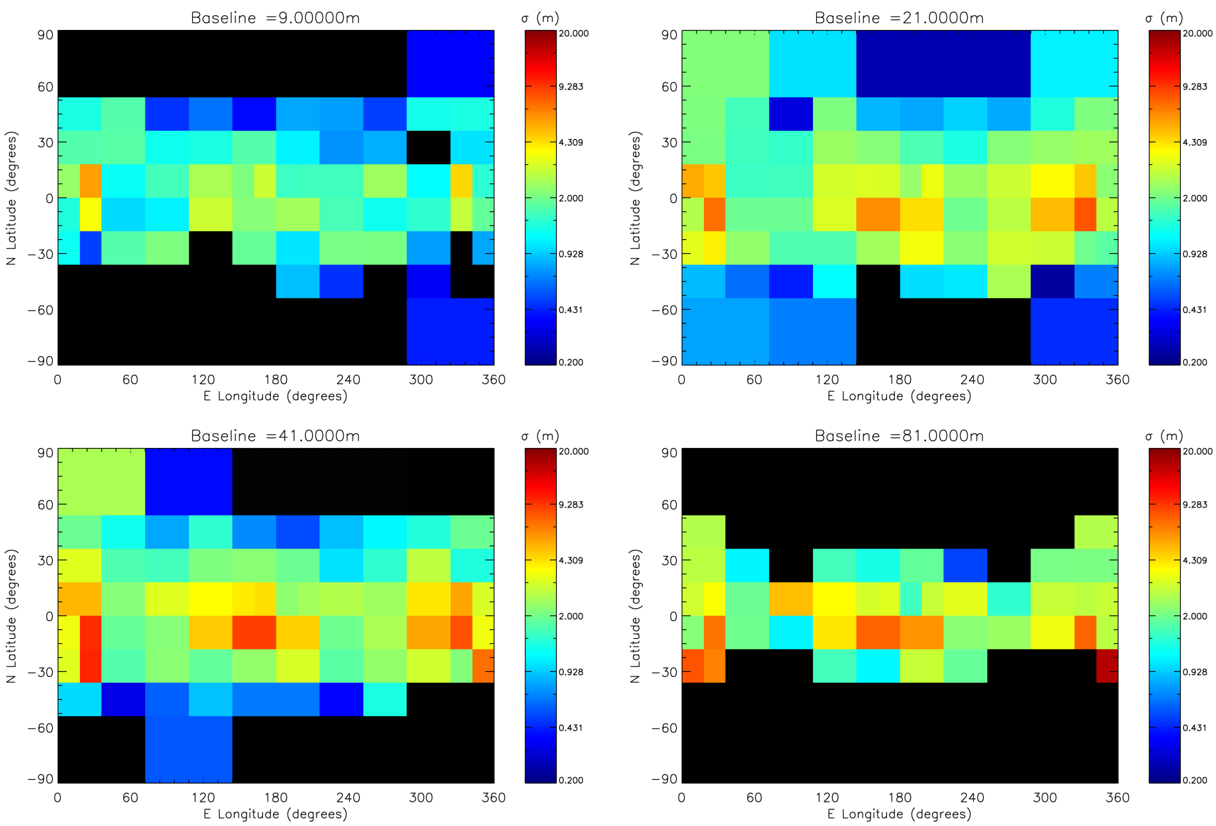

Figure 2. A measure of surface roughness (the standard deviation of height variations) across Itokawa. Longitudinal and latitudinal bins have roughly equal area within a factor of 2. Black means insufficient data.