ASSESSING OSIRIS-REX LASER ALTIMETER (OLA) DATA AND SHAPE MODELS FOR BENNU. J. A. Seabrook[1], M. G. Daly[1], O. S. Barnouin[2], L. Philpott[3], M. Al Asad[3], C. L. Johnson[3,4], R. W. Gaskell[4], E. Palmer[4], E. B. Bierhaus[5], D. S. Lauretta[6]. [1]The Centre for Research in Earth and Space Science, York University, Toronto, ON, Canada, [2]Johns Hopkins University Applied Physics Laboratory, Laurel, MD, USA, [3]Department of Earth, Ocean and Atmospheric Sciences, University of British Columbia, Vancouver, Canada, [4]Planetary Science Institute, Tucson, AZ, [5]Lockheed Martin Space, Littleton, CO, [6]Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ.

Introduction: The OSIRIS-REx (Origins, Spectral Interpretation, Resource Identification, and Security–Regolith Explorer) [1] spacecraft collected data from a near-terminator polar orbit using the OSIRIS-REx Laser Altimeter (OLA) [2] to create a set of high-resolution topographic point clouds covering the entire surface of Bennu. One of the goals of the OLA observations is to produce a high-fidelity global shape model of Bennu. This will be the highest-fidelity global shape of Bennu created by OSIRIS-REx.

Substantial differences were found between shape models produced using stereophotoclinometry (SPC) [3] and those created using OLA data. Efforts to understand the nature of these differences were undertaken, and significant progress has been made in producing a well-registered OLA shape model.

Data Set: During a global mapping phase during July and August of 2019, the OSIRIS-REx spacecraft was in a near-terminator orbit at an average range of approximately 700 meters from the surface of Bennu.

During this phase, OLA collected 892 overlapping raster scans of the surface, each consisting of approximately 3.2 million range measurements. Each of the OLA raster scans utilized identical scan parameters: a mirror field of view of 183 x 174 mrad, with spot spacings of 0.1 mrad at a repetition rate of 10 kHz.

Data Processing: To create the global shape model, offsets between overlapping scans due to uncertainties in spacecraft positions, must be removed. A method utilizing feature detection and matching between overlapping data was developed [4]. These matched features (keypoints) are used to find an optimal rigid rotation and translation for each raster scan that globally minimizes the distances between matched pairs of keypoints.

Shape Model Scales and Aspect Ratios: An initial shape model produced from OLA data (OLA v14) differed in scale and aspect ratio from a SPC produced shape model (SPC v42). Comparisons showed that the OLA v14 shape is overall smaller (Fig. 1) with a difference in radius of ~-2m at the equator, and ~+1.5m at the poles (Fig. 2).

Limb imagery indicated that the aspect ratio of the SPC model was likely correct. After eliminating the processing pipeline as the cause for the discrepancy, investigations into possible errors in the OLA data were undertaken.

The aspect ratio of the OLA v14 shape indicated that the spot spacing in either the fast (azimuth) or slow (elevation) axis of the scan mirror may be incorrect. The mirror azimuth scanned across the spacecraft velocity vector, meaning that the spot spacing along the fast axis is independent of the spacecraft motion and that a scale error in the slow axis of the mirror cloud may be a result of a spacecraft velocity error. The spacecraft velocity was scaled by 0.985 in order to compress the size of the raster scans in the along-track direction. This improved the shape model aspect ratio and scale when compared to the SPC v42 model, but considerable differences remained, and the keypoint residuals (Fig. 3) still showed a strong latitudinal dependence. This magnitude of the velocity error was also determined to be unrealistic. A scale error in the fast axis of the mirror was then investigated. Using the keypoint distance residuals as the minimization metric, a scaling factor of 1.0073 was found to be optimal.

An OLA v16 shape model was produced from the mirror scaled data. Comparisons to SPC v42 show that that the aspect ratio of the shape now closely agrees with the SPC shape (Fig. 4). The OLA shape is smaller by about 30 cm (Fig. 1).

Additional efforts at correcting the OLA shape aspect ratio were undertaken. These include a pole update, latitude dependent adjustment of the point separations to account for new spacecraft positions after global registration, and the construction of OLA shape models using independent methods. These investigations and the results will be presented.

Conclusion: After investigating a number of possibilities, a small scaling error in one of the OLA mirror axes has been found to be the likely cause of discrepancies between shape models created by OLA and SPC. A correction to the mirror azimuth resulted in improved keypoint registration and produced a shape model that matches the expected aspect ratio. Investigations are ongoing to determine a possible cause and to further characterize the nature of the corrections that are to be made.

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References:[1] Lauretta, D. S. et al. (2017) *Space Science Reviews, 212*(1), 925–984. [2] Daly, M. G. et al. (2017) *Space Science Reviews, 212,* 899–924. [3] Gaskell, R. W. et al. (2008) *Meteorit. Planet. Sci. 43,* 1049–1061. [4] Seabrook, J.A. et al. (2019) *Planetary and Space Science, 177,* 104688.

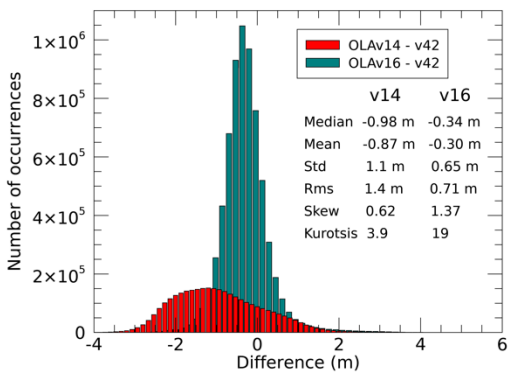

Figure 1. Differences between the SPC v42 and the OLA v14 (red) and v16 (green) shape models.

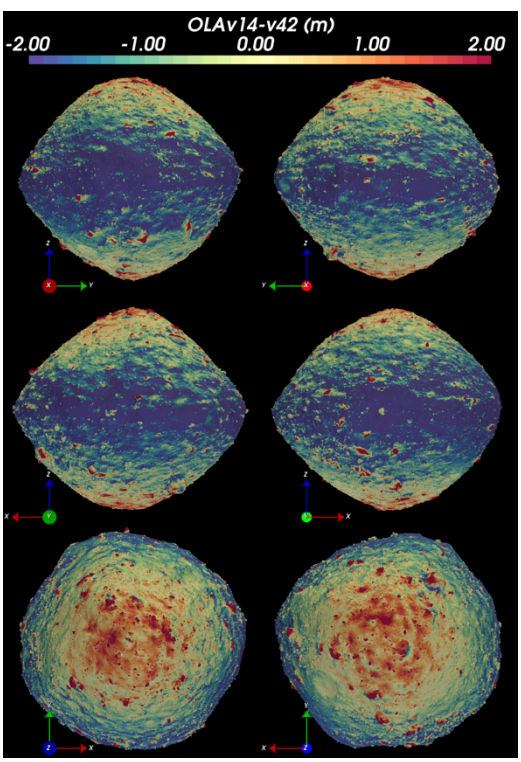

Figure 2. Comparison between the OLA v14 and SPC v42 shape models.

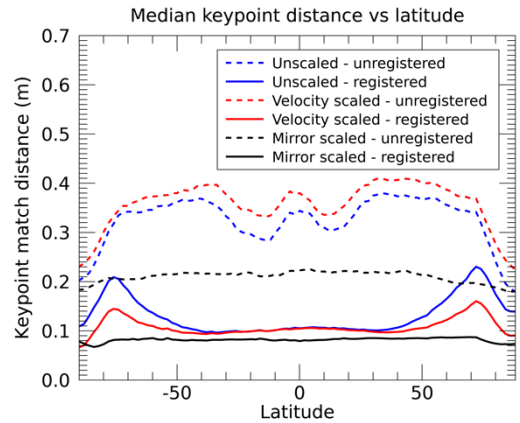

Figure 3. Median distance between keypoint pairs before and after global distance minimization. In blue are the keypoint residuals prior to data correction. In red are the keypoint residuals after spacecraft velocity scaling. In black are the residuals from the velocity-scaled data. Dashed lines and solid lines indicate pre- and post-keypoint registration.

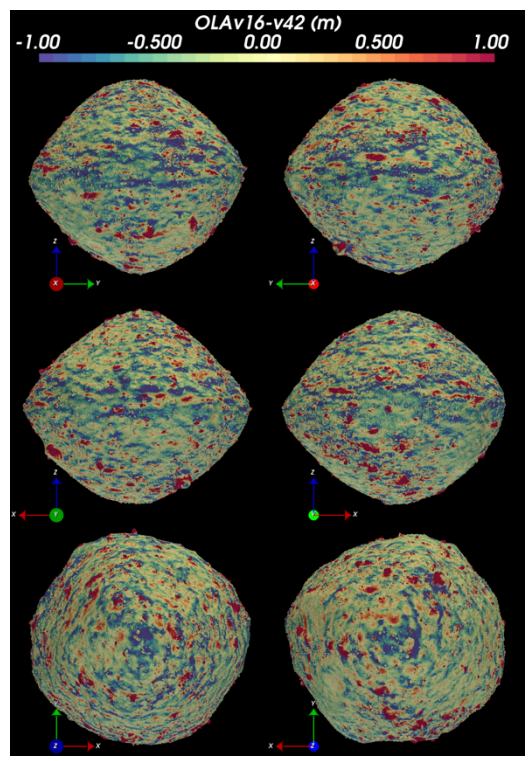

Figure 4. Comparison between the OLA v16 and SPC v42 shape models.