THE OSIRIS-REX LASER ALTIMETER AT >7KM FROM ASTEROID (101955) BENNU. M. G. Daly[1], O.S. Barnouin[2], J. Seabrook[1], C. L. Johnson[3,4], M. Al Asad[4], M. C. Nolan[5], W. Boynton[5], D. S. Lauretta[5], and the OSIRIS-REx Team, [1]York University (4700 Keele Street, Toronto, Ont., Canada, M3J 1P3), [2]Johns Hopkins University Applied Physics Laboratory (11100 Johns Hopkins Rd., Laurel MD, USA; mark.perry@jhuapl.edu), [3]Planetary Science Institute (Tucson, AZ, USA), [4]University of British Columbia (Vancouver, Canada), [5]University of Arizona (Tucson, AZ, USA).

Introduction: The objective of the Origins, Spectral Interpretation, Resource Identification, Security–Regolith Explorer (OSIRIS-REx) mission is to return a sample from asteroid (101955) Bennu [1]. The instruments aboard the OSIRIS-REx spacecraft are measuring the properties of the asteroid to support the investigation of the geophysical and geochemical state of this B-class asteroid, a subclass within the larger group of C-complex asteroids, that might be organic-rich. At approximately 500m in average diameter [2], Bennu has a rocky surface and as an Apollo asteroid with a low inclination (6◦), Bennu is the most accessible primitive near-Earth asteroid.

The OSIRIS-REx spacecraft arrived at Bennu in December of 2018. As part of a suite of instruments on the OSIRIS-REx spacecraft, the OSIRIS-REx Laser Altimeter (OLA [3]; Figure 1) is the world's first scanning laser rangefinder (or lidar) to fly on a planetary mission.

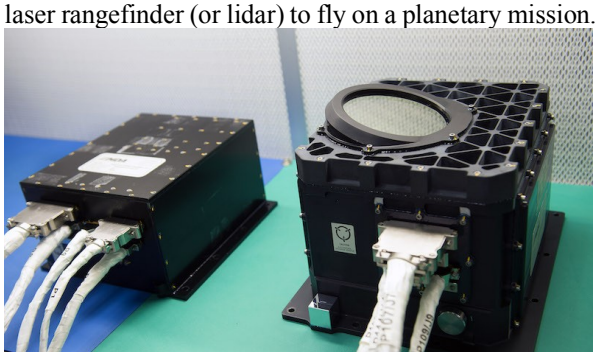

Figure 1: OLA consists of two subassemblies: The optical head unit (right) and the electronics unit (left).

The OLA instrument, provided by the Canadian Space Agency, is very flexible in its ability to collect data because of its long and short-range laser transmitters and its scanning mirror. This flexibility is ideal for continuously improving the fidelity of topographical products generated by OLA and by camera-based stereophotoclinometric (SPC) approaches during the different phases of the OSIRIS-REx mission, as the spacecraft slowly approaches and allows higher-fidelity investigations of the asteroid.

The first operational use of OLA is in the OSIRIS-REx mission phase called Preliminary Survey. This phase consists of a number of fly-bys of the asteroid with close-approach distances above 7km. OLA operates during two north pole (NP) passes, one equatorial (EQ) pass, and one south pole (SP) pass. For each pass, OLA collects data in two periods: one look-ahead and one look-behind. At the closes approach, OLA does not take data due to the need for other spacecraft operations during that time.

OLA has two primary tasks during these flybys. It supports the navigation of the spacecraft through direct range-measurements of the asteroid. It also allows for independent assessment of the stereophotoclinometric shape model primarily by assessment of model scale errors.

Results: OLA returned 3256 range measurements to Bennu at an average range of 7.18 km. The range measurements are registered to an SPC-derived shape model (Figure 2). Details for each pass are presented in Table 1.

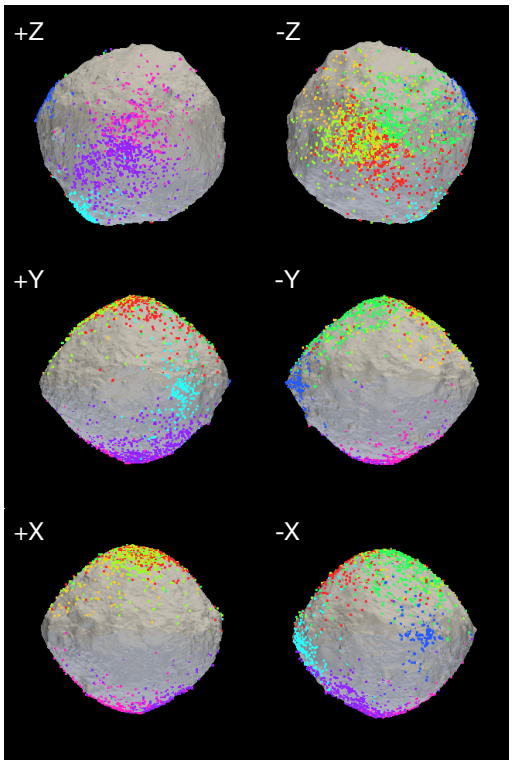

Figure 2: OLA returns on an SPC-derived shape model with look directions shown and each continuous OLA dataset shown in separate colors.

The returns from each of the three types of passes were evaluated against the best available shape model to assess the overall scale error of the model. The data from each inbound and outbound pass were, after correction for spacecraft and asteroid rotation each registered using a rigid transformation and rotation to the shape model at various scales. The goodness of fit was assessed using the RMS of the residuals between the fitted point-cloud and the scaled shape model. Fewer returns in the EQ pass provide less assurance as to the scale in the north-south direction.

Table 1: OLA measurement statistics.

Pass	*OLA Measurements*	*Average Range*	*False Returns*
NP1	856	7.39	3
NP3	1097	7.19	7
EQ	344	7.09	6
SP	959	7.00	5

The OLA data provides confirmation that the shape model well approximates the shape with assessed scale errors of between 0 and -0.5% (i.e. the model may be slightly small).

References: [1] Lauretta D. S. et al. (2017) *Space Sci. Rev.,* 212:925. [2] Lauretta D. S. Met. Plan. Sci., 50: 834-849. [3] Daly M. G. et al. (2017) *Space Sci. Rev.,* 212:899.

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