PHOTOMETRIC MODELING OF SIMULATED SURFACE-RESOLVED BENNU IMAGES. D. R Golish[1], D. N. DellaGiustina[1], B. E. Clark[2], C. A. Bennett[1], J-Y Li[2], X-D Zou[2], and D. S. Lauretta[1], [1]Lunar and Planetary Laboratory, University of Arizona (dgolish@orex.lpl.arizona.edu), [2]Department of Physics and Astronomy, Ithaca College, [3]Planetary Sciences Institute

Introduction: The Origins Spectral Interpretation Resource Identification Security Regolith Explorer (OSIRIS-REx) is a NASA mission to study and return a sample of asteroid 101955 Bennu [1]. Upon its arrival in late 2018, a series of observation campaigns will study Bennu with a suite of instruments, including the OSIRIS-REx Camera Suite (OCAMS). OCAMS is comprised of a trio of cameras – SamCam for sample acquisition documentation; MapCam for surface mapping, and PolyCam for high resolution imaging. The Detailed Survey campaign will capture images of the surface over a range of illumination angles with MapCam. These data will be used to develop empirical surface-resolved photometric models of Bennu at each of the observation wavelengths (closely matching the ECAS *b*, *v*, *w*, and *x* bands, as well as panchromatic). The models will be used to photometrically correct panchromatic and color basemaps, which can be used to compensate for variations in images due to shadowed regions, emission and incidence angle differences, and surface reflectance, thereby minimizing seams in mosaicked images. Well-corrected mosaics are critical to the generation of the global hazard map and the 1064 nm global mosaic – two data products that feed directly into the mission's ability to safely select and approach a sample site.

Simulated Photometry: Simulated MapCam imagery has been created to test the photometric modeling pipeline. For this work, simulated images from the baseline mission plan for Detailed Survey, with phase angles from 10 to 90°, are used to derive empirical photometric models. A sample simulated image from this phase is shown in Fig. 1. Images are generated using the OSIRIS-REx Stereophotoclinometry (SPC) software suite [2]. SPC assumes a Lunar-Lambert photometric model, but the model parameters are unknown to participants in this work. Solving for those parameters is therefore a blind test that will act as a verification of the modeling process.

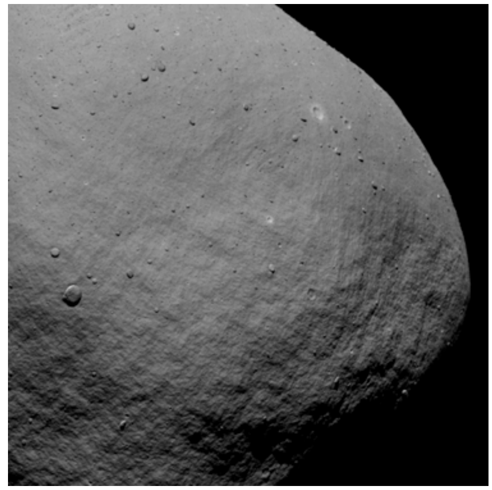

Figure 1. Simulated MapCam image of Bennu, observed with an average phase angle of 45°, during the Detailed Survey mission phase.

Observation geometry of the simulated images is calculated in Integrated Software for Imagers and Spectrometers (ISIS) [3]. Mean reflectance, phase angle, emission angle, and incidence angle are calculated for each image. Plotting the relationship between these parameters, as shown in Fig. 2, demonstrates the coverage achieved by the current observation design.

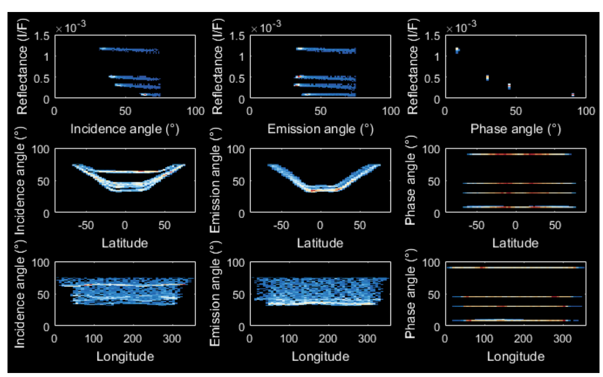

Figure 2. Photometric coverage is evaluated by plotting reflectance as a function of incidence, emission, and phase angle (top row). Surface coverage is shown as a function of photometric angles (middle and bottom rows).

Photometric Modeling: Analysis of this data is performed using custom Interactive Data Language (IDL) programs that fit reflectance and observation geometry data with four photometric models: Lommel-Seeliger, Minnaert, Modified Lunar-Lambert, and Robotic Lunar Orbiter (ROLO) [4]. The accuracy of the models is measured as the ratio of the reflectance predicted by the model to the mean reflectance “measured” in the images, as shown in Fig. 3 (for the Lommel-Seeilger model). Perfectly modeled data would lie exactly on the blue line. Departures from this line are indicative of flaws in the model. These flaws are largely due to the model failing to capture reflectance variation as a function of emission and incidence angle; phase angle variation is captured very well.

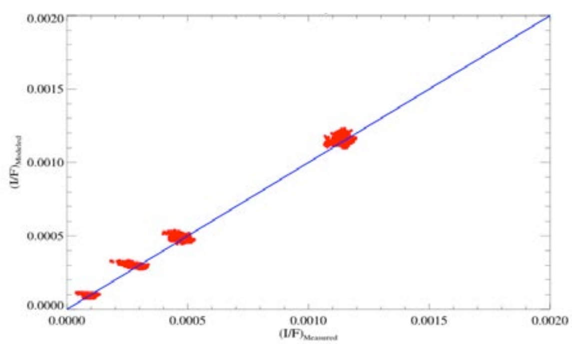

Figure 3. Photometric modeling accuracy is measured by calculating the ratio of predicted to measured reflectance. Here the results of the Lommel-Seeliger model are plotted.

Photometric Correction: The photometric models are used to photometrically correct simulated imagery as an operational test of their utility. Two example mosaics, shown in Fig. 4, were created without photometric correction (top) and with the Lommel-Seeliger model calculated from the simulated data (bottom). A perfectly corrected model would show no terrain features or seams between images. Uncorrected terrain and a bright equatorial band in the corrected mosaic indicate weaknesses in the model.

Future work: The photometric angle coverage shown in Fig. 2 demonstrates a lack of phase angle diversity between 45 and 90 degrees. This will feed back into mission planning and potentially prompt additional observations to meet this need. Further investigation is also required to determine if the imperfect photometric corrections are a result of poor modeling or errors in the simulated data itself. Processing the simulated data through the photometric pipeline not only acts as a test of the software itself, but also exercises planned activities for proximity operations.

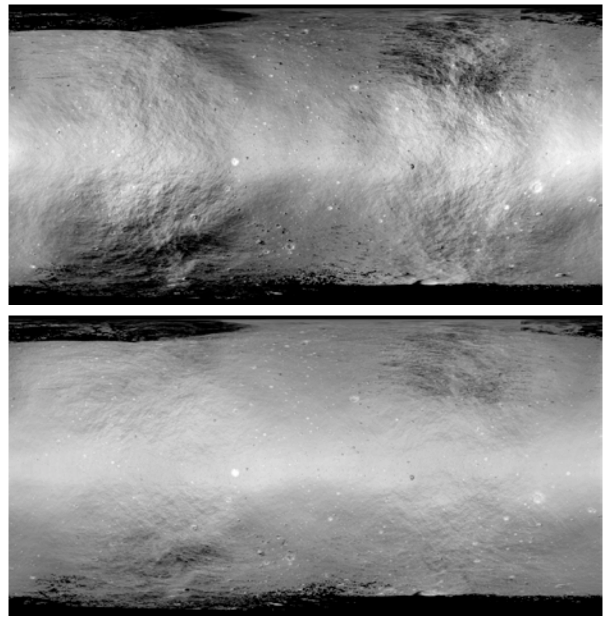

Figure 4. Global mosaics of simulated Bennu imagery uncorrected (top) and corrected (bottom) demonstrate the efficacy of the Lommel-Seeliger model.

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References: [1] Lauretta, D. S (2015) *Handbook of Cosmic Hazards and Planetary Defense,* 543-567. [2] Gaskell, R. W., (2005), *JPL, NASA*. [3] https://isis.astrogeology.usgs.gov [4] Takir, D., et al., (2015), *Icarus, 252,* 393-399.