MRD 183a- Global 1064nm Reflectance Map

Data Product Names:

Global 1064nm Reflectance Map

Site Specific 1064nm Reflectance Maps

Note: The site-specific maps – from Recon 525m MapCam and OVIRS data – only provide validation that the selections of the prime and back-up sites were robust to this criterion because they are available too late to influence site selection.

Working Group Creating the Map: Image Processing Working Group (IPWG) working with the Photometric Modeling Working Group (PMWG), and using input from the Spectral Analysis Working Group (SAWG).

Source Data Descriptions:

Baseline: The maps are created from global OCAMS observations obtained during Detailed Survey (MapCam X-filter at 860nm), scaled by a mapped (spatially variable) OVIRS multiplicative factor (1064nm/860nm) to convert from 860nm 1064nm.

Motivation for the Data Product

The Safety Map WG needs to know the reflectance of the asteroid at 1064nm to ensure that the surface that will be observed with lidar to determine range to surface is within the range of reflectance values in which the LIDAR is designed to operate. Predictions of the variation in intensity are also important to enabling avoidance of excessively high variations in reflectance that could affect LIDAR ranging performance.

Baseline:

Image Maps go through the following data processing flow within the Image Processing Working Group (IPWG). For more details about this processing please see the Color-Ratio Maps page of the IPWG:

1) From the IPWG Multispectral Cubes, we will separate out the X-filter Images so that we have single wavelength images.

2) Next we build a control network between a set of X-filter images and use that network to photogrammetrically register the images. This gives us information about the relative orientation of the images.

3) The next step is to photometrically correct the images.

4) Then map-project all the images,

5) The final step is to align all the images for mosaicking.

Maps will be composed of Imaging data (Spatial information) converted from units of I/F (at variable observation geometries) to units of r (Bidirectional Reflectance) at LIDAR viewing geometry (Photometric information) and scaled to the LIDAR observation wavelength (Spectral information):

SPATIAL INFORMATION: MapCam 860 nm (filter x) global mosaics from the 12:30pm station of the Detailed Survey mission phase, and RECON 525m site-specific mosaics.

PHOTOMETRIC INFORMATION: A Photometric Model of the MapCam 860 nm data, obtained from fitting models to the data from the 12:30pm (5 degrees) station of Detailed Survey (other stations are backup - for filling gores or gaps in the 12:30 station data. The main backup datasets will come from: 10am (30 degrees), or 3pm (45 degrees).

• The GN&C Lidar observations will be measured in units of Z=URDF*cosine(i), which is the same quantity as RADF(e,e,0)/π, or, more commonly, "little r": r(e,e,0) - the bidirectional reflectance at zero phase, where incidence angle is the same as emission angle.

• Therefore, we will supply maps with pixels in units of Bidirectional Reflectance (or Radiance Factor divided by Pi): $RADF(i,e,\alpha)/\pi = I/F(i,e,\alpha)/(\pi) = BRDF(i,e,\alpha)*\cos(i) = r(i,e,\alpha)$.

• $r(i,e,\alpha)$ evaluated at $\alpha = 0$ degrees phase angle, i = -e -> r(e,e,0) for two cases:

• i = e = 0 degrees, a = 0 degrees

• i = e = 70 degrees, a = 0 degrees

• Each Bidirectional Reflectance calculation will produce minimum, maximum, and nominal predictions for the returned LIDAR signal, based on the uncertainties and propagated errors of the imaging, photometric modeling and photometric correction process.

• Note that for all empirical models being used by our project (Lommel-Seeliger, Minnaert, and ROLO), the Bidirectional Reflectance for a dark surface is essentially the same for i = e = 0 degrees, and i = e = 70 degrees. This counter-intuitive result means that our model predictions are independent of incidence angle.

SPECTRAL INFORMATION: Following conversion to units of Bidirectional Reflectance, the data will be scaled from 860 to 1064nm using scaling factors derived from OVIRS observations obtained during Detailed Survey. Scale factors will capture the distribution in 1064/860 color ratios across the asteroid as a function of rotational longitude – resulting in minimum, maximum, and nominal scaling factors to be applied to the minimum, maximum, and nominal models, respectively. Global scale factors will be calculated using data obtained for the MRD-159 SAWG Data Product entitled "Rotationally Resolved Spectral Characterization" of Bennu.

Contingency:

This option will be exercised if the variation in spectral response over TBD spatial scales exceeds TBD. Maps will be composed of Imaging data (Spatial information) converted from units of I/F (at variable observation geometries) to units of r (Bidirectional Reflectance) at LIDAR viewing geometry (Photometric information) and scaled to the LIDAR observation wavelength (Spectral information):

SPECTRAL INFORMATION: Following conversion to units of Bidirectional Reflectance (r) the data will be scaled from 860 to 1064nm using the color ratio of the 1064nm/860nm channels for each OVIRS spectral footprint obtained simultaneously with the MapCam data. Each OVIRS spectrum will be photometrically corrected to the same units and viewing geometry as the overlapping MapCam pixels before color ratios are calculated.   In this scenario, color scale factors will be single values, not bounding cases.

Validation:

Baseline:

The IPWG is developing software to make color maps in the ECAS b', v, w, x, band passes for both the Baseline and Contingency options using relevant spectral and/or imaging test data sets.

The Photometric Modeling sub-Group of the IPWG will develop the photometric transform to apply to the x-band map for creating the 1064-nm Bidirectional Reflectance predictions used in the Baseline and Contingency options using relevant spectral and/or imaging test data sets.

The Safety Map Working Group will test and validate results by comparison with the published literature on Lidar observations.

Test Data:

There are several possible approaches to test data:

We may choose to generate fake data that are representative of the kinds of observations that we will obtain with the OCAMS, OVIRS, and GNC Lidar instruments. A synthetic photometric package such as synphot or pyphot may be used to create a photometric transform to convert the OCAMS 860-nm (x-filter) color map to a 1064-nm color map. Input data for the synthetic photometry package include:

a) OCAMS detector responsivity

b) OCAMS optical and filter transmission curves

c) GN&C lidar bandpass curve at 1064-nm

d) Spectra of Bennu from ground based observations

We may choose to use Eros NIS (and MSI?) data from the NEAR-Shoemaker mission. We would use the Small Body Mapping Tool to identify an appropriate test data set where both instruments obtained data that will be similar in kind to the Detailed Survey and RECON observations at Bennu.

We will write the software to process the Spectral and Imaging data, including generating and using photometric models of the target, and we will present results to the Safety Map Working Group so that they can validate and verify our approach (e.g. via comparison with actual NEAR Eros NLR signals).

This wiki page is written by Beth Ellen Clark, Mission Asteroid Scientist, 5 April 2016.