PHOTOMETRIC MODELING OF SIMULATED SURFACE-RESOLVED BENNU IMAGES

Dathon Golish
Daniella DellaGiustina
Beth Clark
Carina Bennett
Jian-Yang Li
Xiao-Duan Zou
Dante Lauretta

1Lunar and Planetary Laboratory, University of Arizona
2Department of Physics and Astronomy, Ithaca College
3Planetary Sciences Institute, Tucson, AZ
OSIRIS-REx

• Launched on September 08, 2016

• Arrives at Bennu in late 2018
• OSIRIS-REx is unique in that all of its data products are driven by sample site selection

• The pace of production is also driven by the timeline to prepare for sampling

• This emphasizes the need for robust and timely creation of the products that are inputs to the selection process
TOP LEVEL MAPS

Safety

Deliverability

Sampleability

Science Value

Sample Site Selection
TOP LEVEL MAPS

Safety
- Shape model
- Dust/gas plumes
- Albedo map
- Surface temperature

Sampleability
- Tilt map
- Grain size map
- Thermal inertia
- Hazard map

IPWG Data Products
- Albedo map
- Hazard map
TOP LEVEL MAPS

- 1064 nm albedo/reflectance map
  - IPWG will generate a global mosaic with MapCam’s X filter, which is extrapolated to a 1064 nm reflectance map using photometrically corrected OVIRS data
  - The reflectance map is used by the Guidance, Navigation & Control LIDARs to ensure safe descent to the surface

- Hazard map
  - IPWG will produce a global map indicating regions of interest and regions of exclusion on the surface

- Both the albedo and hazard maps depend on an accurate photometric model
SIMULATED DATA

- The observation plan and photometric modeling pipeline are tested with simulated data using planned observation kernels

- The Equatorial Stations observation campaign provides global coverage at four phase angles with MapCam in all filters

6 am 10 am 12:30 pm 3 pm
**Simulated Data**

- Simulated data is created using USGS ISIS

![Diagram](image)

- Emission Angle
- Phase Angle
- Incidence Angle

*Inverse photometric correction*
Simulated Data

Limitations

- Obscurations
  - Uses single-surface ray tracing – obscurations will not produce shadows
- Albedo
  - Uses one photometric model for the entire surface – i.e. no albedo variation across the surface
- Resolution
  - Uses the DSK shape model, which has a size limitation

Advantages

- Accurate
  - Produces photometrically and radiometrically accurate images
- Flexibility
  - Photometric models parameters are easily changed by editing a text file
  - New models also can be added with minimal bash/ISIS scripting
- Dynamic range
  - Images are created in 32 bits
- Evaluate the photometric coverage achieved by the observation plan as designed
PHOTOMETRIC MODELING

• Modeling software is written in IDL
  • Fits several photometric models to the phase, emission, incidence, and reflectance data
  • Lommel-Seeliger shown in plots
PHOTOMETRIC MODELING

\[ I/F(\alpha, i, e) = \frac{A_{LS} \cos(i)}{\cos(i) + \cos(e)} e^{\beta \alpha + \gamma \alpha^2 + \delta \alpha^3} \]

Simulation Parameters
- \( A_{LS} = 0.030 \)
- \( \beta = -0.0433 \)
- \( \gamma = 2.64 \times 10^{-4} \)
- \( \delta = -9.67 \times 10^{-7} \)

Modeled Parameters
- \( A_{LS} = 0.0302 \)
- \( \beta = -0.0436 \)
- \( \gamma = 2.5408 \times 10^{-4} \)
- \( \delta = -8.1734 \times 10^{-7} \)
• Though the images are simulated with Lommel-Seeliger, fitting to other common photometric models is also successful
• The disk-integrated phase functions for the other models verify that they fit fairly well to the Lommel-Seeliger data

• McEwen deviates slightly at mid-phase angles, due to its two-part disk function
Photometric correction is applied in ISIS

- The error in correction is best judged by the uniformity of a mosaic of photometrically corrected images
- A perfectly corrected mosaic will represent only the albedo of the surface (which is uniform), without any topography
• Additional data
  • Simulate potential contribution of additional observations during the mission to fill in gaps in the phase function

Add observations from Approach and Preliminary Survey
• Photometric models
  • Add Akimov model to both simulation and modeling software

\[
(A_1 * e^{-\mu_1 \alpha} + A_2 * e^{-\mu_2 \alpha} + A_3 * e^{-\mu_3 \alpha}) \left[ \cos \left( \frac{\alpha}{2} \right) \cos \left( \frac{\pi}{\pi - \alpha} \left( \gamma - \frac{\alpha}{2} \right) \right) \frac{\cos(\beta)^{0.5 \alpha}}{\cos(\gamma)} \right]
\]

Phase Function

Disk Function

Akimov

Lommel-Seeliger
Future Work

- Perturbed data
  - Simulated images are essentially perfect
  - Modeling software can be exercised by purposefully perturbing the photometric/reflectance data
**FUTURE WORK**

- Increase fidelity of simulator
  - Simulated images are limited by resolution of DSK
    - Investigate creation of a higher resolution DEM
  - There is no albedo variation in the simulation, leading to flat photometrically corrected mosaics
    - Explore options for adding large scale albedo variations to simulation
THANKS!
BACKUP SLIDES
OSIRIS-REx Camera Suite (OCAMS)

MapCam

PolyCam

SamCam