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Thermal Inertia Maps of (101955) Bennu from OSIRIS-REx Infrared Observations

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Abstract

OSIRIS-REx has obtained spatially-resolved infrared observations of asteroid (101955) Bennu from the mission's Detailed Survey phase. We produced thermal inertia maps of Bennu from these observations by using a thermophysical model, and we find definitive spatial variations in Bennu's thermal inertia.

1. Introduction

Asteroid (101955) Bennu is the target of NASA's OSIRIS-REx mission, which will return a sample of ≥60 grams of regolith from its surface [1]. Before picking up the sample from the surface, OSIRIS-REx will have spent more than a year characterising the surface with cameras, spectrometers, and the laser altimeter that are onboard the spacecraft. The primary data set to be used for thermophysical analyses are thermal spectra from the OSIRIS-REx Thermal Emission Spectrometer (OTES) [2]. Additionally, the long-wavelength end of spectra obtained by the OSIRIS-REx Visible and InfraRed Spectrometer (OVIRS) will also be dominated by thermal emission [3].

From the Approach phase of the mission, disk-integrated data returned by OTES and OVIRS confirmed the previous Spitzer-based thermal inertia measurement of Bennu [4]. In particular, a thermal inertia of 350 ± 20 J m^{-2} K^{-1} $s^{-1/2}$ and a surface roughness RMS slope of 43 ± 1° were derived from OSIRIS-REx thermal emission lightcurves and the updated shape model of Bennu [5]. These observations also found no significant variations in thermal inertia, or surface roughness, with rotational phase.

While the Approach-phase observations rule out large hemispheric differences in thermal inertia, they do not rule out smaller-scale variations. During the Detailed Survey phase of the mission, OTES and OVIRS measured the infrared radiation from the surface at ~20- to ~40-m spatial scales, enabling us to produce detailed maps of thermal inertia and roughness for the entire surface of Bennu. Such maps will aid in the interpretation of local variations seen in the geology and/or composition on the surface of Bennu.

2. Observations & Methods

During the Detailed Survey phase, OTES and OVIRS observed the surface of Bennu at seven different local times of day (i.e. 3:20am, 6am, 10am, 12:30pm, 3pm, 6pm, and 8:40pm). Thermophysical analysis of these data was carried out with a custom thermal model that is based on the Advanced Thermophysical Model of Rozitis and Green [6,7,8]. See Figure 1 for an example comparison between predicted and observed brightness temperatures for a 12:30pm station.

3. Results

An initial analysis using data collected from the first "baseball diamond" station on 7 March 2019 finds definitive spatial variations in thermal inertia. In particular, local thermal inertia values range from ~200 to ~500 J m^{-2} K^{-1} $s^{-1/2}$ whilst the global average thermal inertia value remains ~350 J m^{-2} K^{-1} $s^{-1/2}$. Unexpectedly, the lowest thermal inertia values are associated with the largest boulders on Bennu, and the highest thermal inertia values are found on some of the smoother regions on Bennu. This unexpected result prompts a re-evaluation of the interpretation of thermal inertia for small rubble-pile asteroids, and provides insight into the nature of the unusual boulders found on the surface of Bennu [9].

4. Summary and Conclusions

We will present the thermal inertia maps produced by our thermophysical analyses of the OSIRIS-REx infrared observations, and we will also discuss the new maps in context with other results.

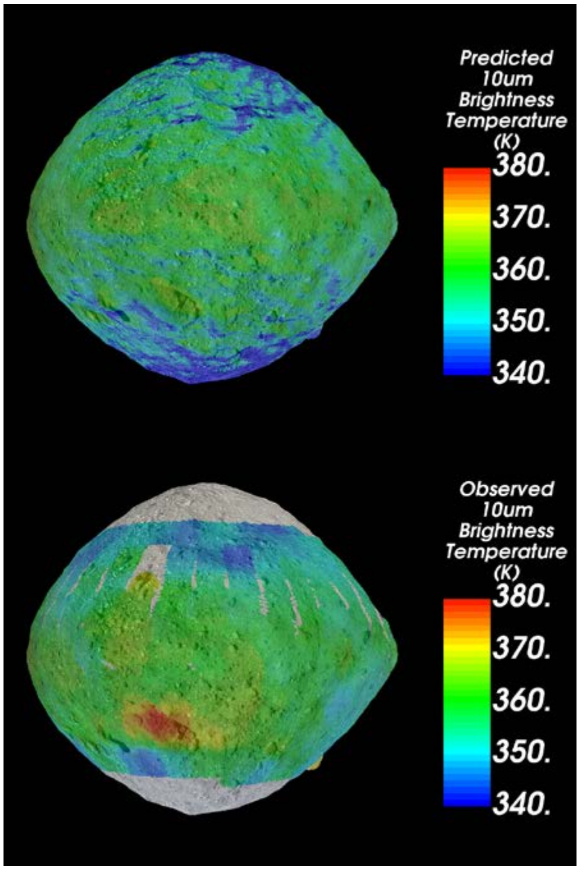

Figure 1: (a) Predicted 12:30pm 10-µm brightness temperatures for a uniform thermal inertia of 350 J m^{-2} K^{-1} $s^{-1/2}$. (b) 10-µm brightness temperatures as observed by OTES. Differences between the two images indicate the presence of local variations in thermal inertia.

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