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Classification of Ceres HST albedo deviation map

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Abstract

With a mean diameter of 952 km, dwarf planet Ceres is the largest object in the main asteroid belt. Here we classify Hubble Space Telescope (HST) albedo deviation map of Ceres calculated in three bands, using the Spectral Angle Mapper (SAM) classification method. The data are available in the PDS Small Bodies Node and are described in [1]. Our classification allows the identification of regions of interest on Ceres, and to distinguish areas with similar spectral characteristics. Our work is in support of the arrival of the Dawn spacecraft at Ceres in 2015.

1. Introduction

NASA's Dawn mission to Vesta and Ceres will approach Ceres in the spring 2015 [2]. The spacecraft carries a visible and infrared imaging spectrometer (VIR) [3] that will allow determination of the objects's surface mineralogy. Ground-based telescopic studies of Ceres [4, 5] reveal the great differences in composition between Ceres, and the other two largest asteroids of the main belt, Pallas and Vesta [5]. Theoretical modeling of the spectral properties of carbonaceous chondrites [6, 7, 8], and the discovery of the presence of hydration features [7], reveal the connection between Ceres spectra and those of the hydrated meteorites. The derived, relative albedo map of Ceres obtained by HST observations, revealed different albedo regions [1]. Here we classify this map to study the homogeneity of Ceres's surface and the connection between the different regions.

2. Data set description and analysis

In this work we use the albedo deviation map derived by [1]. The data are available in the NASA PDS Small Bodies Node in three wideband filters centered at 223 nm, 335 nm and 535 nm, respectively, with a spatial resolution of 30 km/pixel, and represent the deviation of each band from the visual geometric albedo of Ceres [1, 9]. We build a file with the three maps and we apply the SAM classification method [10, 11]. To select the endmemembers we used the ISODATA clustering method. ISODATA is an unsupervised method, and is useful when no a priori informations are available on the statistical universe under consideration, and can be used to properly extract the endmembers for the supervised classifications [10]. The algorithm automatically selects clusters of data sharing similar values in the multi-dimensional parameter space [10]. Here we applied the ISODATA to automatically extract the spectral endmembers. We then selected a plausible number of homogeneous spectral units, comprised between 3 and 10. Finally, we used the spectral endmembers derived by ISODATA to classify the albedo map with the SAM supervised classification method [11, 12]. SAM compares every single spectrum in the dataset with the spectral endmembers to determine their degree of similarity, by computing a "spectral angle" between them [10, 13]. The spectra are considered as vectors in a space with dimensionality equal to the number of bands. SAM considers only the direction of the spectra [10, 13].

3. Results

ISODATA clustering method identifies six spectral endmembers (Fig. 1, 2). In **Fig. 1** and **2** we show results obtained from the SAM classification using the spectral endmembers extracted with ISODATA. In our case, SAM detects four different areas: **Region A**, located between 0°E and 180°E, is largely variegated, all spectral units being represented in this area. **Region B** (180°E-270°) is rather homogeneous and is represented by one unit (blue); **Region C** (270°E-360°) is similar to Region A but includes a smaller number of units (red, green, yellow, with small magenta areas). Finally, **Region D** is located between regions A and C, and is represented by the same units of region B (blue). SAM classifier allowed us to distinguish areas with homogeneous spectral characteristics. The results obtained with the Hubble data must be considered in light of the small number of bands and the relatively limited spectral range. The work presented here provides a preview of the type of analysis that can be conducted when VIR data of Ceres become available.

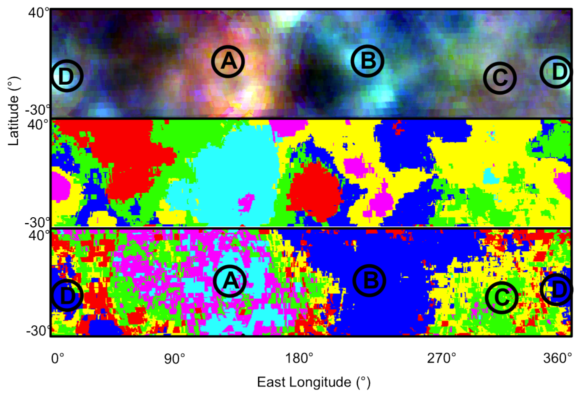

Figure 1: Top: RGB image of the Ceres albedo deviation. R: 535 nm, G: 335 nm, B: 223 nm. Middle: Endmembers found with ISODATA. Bottom: Results of the SAM classification.

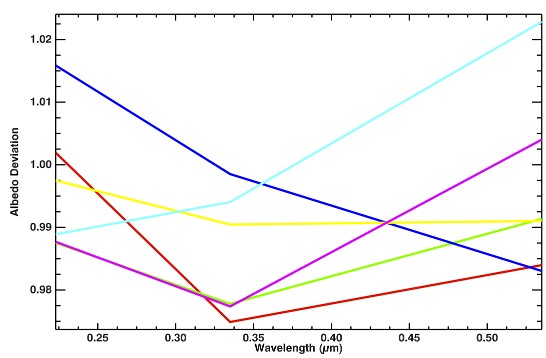

Figure 2: Mean spectra of the classes relative to the SAM classification.

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References

[1] Li, J.Y. et al.: Photometric analysis of 1 Ceres and surface mapping from HST observations, Icarus, 182, 2006. [2] Russell, C. T. and Raymond, C. A., 2011, The Dawn Mission to Vesta and Ceres, Space Sci. Rev., 163, 2011. [3] De Sanctis, M. C. et al.: The VIR Spectrometer, Space Sci. Rev., 163, 2011. [4] Rivkin, et al.: The surface composition of Ceres: Discovery of carbonates and iron-rich clays, Icarus, 185, 2006. [5] Rivkin, et al.: The surface composition of Ceres, Space Sci. Rev., 163, 2011. [6] Johnson, T.V. and Fanale, F.P.: Optical properties of carbonaceous chondrites and their relationship to asteroids, JGR, 78, 1973. [7] Lebofsky, L.A.: Asteroid 1 Ceres: Evidence for water of hydration. Mon. Not. R. Astron. Soc. 182, 1978. [8] Lebofsky, L.A., et al.: The 1.7- to 4.2-micron spectrum of Asteroid 1 Ceres-Evidence for structural water in clay minerals, Icarus, 48, 1981. [9] Cruikshank, D. P. and Morrison, D.: Radii and albedos of asteroids 1, 2, 3, 4, 6, 15, 51, 433, and 511, Icarus, 20, 1973. [10] Adams, J. B. and Gillespie, A. R.: Remote Sensing of Landscapes with Spectral Images: A Physical Modeling Approach, Cambridge University Press, 2006. [11] Scipioni, F. et al.: Spectroscopic classification of icy satellites of Saturn I: Identification of terrain units on Dione, Icarus, 226, 2013. [12] Scipioni, F. et al. 2014: Spectroscopic classification of icy satellites of Saturn II: Identification of terrain units on Rhea, Icarus, 234, 2013. [13] $http://www.ltid.inpe.br/tutorial/tut9.htm\#Spectral\%20Angle\%20Mapper\%20Classification$[]