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Spectroscopic identification of Dione' and Rhea' terrain units using Cassini VIMS data

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Since July 2004, the Cassini spacecraft performed several observations of Saturn's icy satellites, allowing a better insight of their compositional and physical characteristics. The Visual and Infrared Mapping Spectrometer (VIMS) is a spectrometer onboard the Cassini Orbiter.

In this work, we have selected 76 VIMS cubes of Dione and 166 cubes of Rhea in the infrared range 0.85-5.1 μm. These data are characterized by a phase angle smaller than 50° and a good S/N ratio. After normalizing all data at λ=2.232 μm to minimize photometric effects, we apply the supervised Spectral Angle Mapper (SAM) clustering technique to emphasize the existence of spectral units. Initially, for each satellite we define two end-members, respectively represented by one spectrum (one pixel) of a low-albedo terrain and one spectrum (one pixel) of a high-albedo terrain as seen at high spatial resolution. In the SAM method applied to remote sensing data, each spectrum is represented by a vector in the n-dimensional coordinate system, where n is the number of spectral channels. To compare the spectrum of each pixel of the target with the reference spectra selected a priori, the algorithm evaluates an angle θ that represents the separation between the vector of the reference spectrum (reference pixel) and the vector representing another pixel's spectrum in the data space. Small values of θ are indicative of a higher degree of similarity between the data. We set θ=0.1^o as the maximum allowed angle value. In the cases detailed here, because two reference spectra/pixels show up to be not representative of the entire surface of the satellites, further a priori end-members are added until the whole surface as imaged by VIMS is properly classified. In particular, we select 9 and 12 different terrain types for Dione and Rhea, respectively.

For both satellites, the infrared spectrum is dominated by the prominent signatures of H_2O ice / OH bands at 1.5, 2.0 and 3.0 μm. For Rhea the spectral signatures due to water ice at 1.04 and 1.25 μm are observed on the overall surface, while for Dione these features are present just on a few percentage of the surface.

A classification method applied to VIMS hyperspectral data is crucial to understand geochemical processes taking place on the surface of the icy satellites. The goal of this work is to investigate the possible presence on the surface of Dione and Rhea of non-water ice material, such as methane and ammonia. From the classification we find several spectral units on the two satellites characterized by different values of the spectral indices (e.g., water ice bands' depth, reflectance of the 3.6 μm peak). Finally, some classes show also a peculiar trend with respect to the phase angle, possibly related to the physical structure of the surface constituents (e.g, average grain size of the surface regolith).