EPSC Abstracts,
Vol. 4, EPSC2009-18, 2009
European Planetary Science Congress,

Spectral investigations of the Saturn system icy satellites by Cassini-VIMS

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Abstract

During the first 5 years of the Cassini mission the VIMS experiment, Visual and Infrared Mapping Spectrometer, has obtained a comprehensive hyperspectral view of the icy objects of the saturnian system. In this period a statistically representative dataset of hyperspectral data (about 1500 observations) has been collected in the 0.35-5.0 μm spectral range, including the disk-integrated reflectance spectra of the regular satellites Mimas, Enceladus, Tethys, Dione, Rhea, Hyperion, Iapetus and of the minor moons Atlas, Prometheus, Pandora, Janus, Epimetheus, Telesto, Calypso and Phoebe. These data are investigated and classified by using several spectrophotometric indicators chosen ad hoc to describe the macroscopic properties of the ices: I/F continuum levels, visible spectral slopes, band depths and positions [1, 2]. This comparative method allows us to classify the spectral characteristics of this population of objects orbiting in the Saturnian system as well as to measure their radial variability across the system. This research was supported by an Italian Space Agency (ASI) grant.

Disk-integrated I/F spectra of the satellites

The average reflectance spectra (shown in Figure 1) are retrieved through a statistical analysis of the disk-integrated observations of the icy satellites made by VIMS [2]. Satellites spectra are characterized by a step red slope in the 0.35-0.55 μm which is highly diagnostic of the presence of organic contaminants and darkening agents on their icy surfaces. In the IR range is possible to recognize the water ice bands, in particular the 1.5-2.0-3.0 μm bands are evident everywhere.

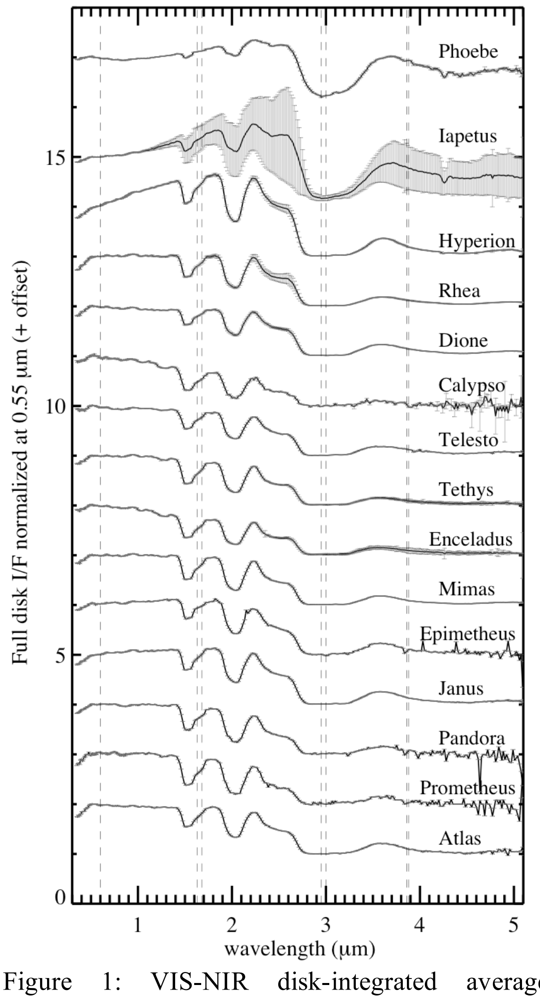

Figure 1: VIS-NIR disk-integrated average reflectance spectra (± 1σ) of the saturnian icy satellites. Spectra are normalized to 1 at 0.55 μm and stack with an offset for clarity. The satellites are sorted according to their distance from Saturn. Vertical lines indicate the spectral position of the instrumental order sorting filters.

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The CO_2 ice band at 4.26 µm is seen only on the three external satellites Hyperion, Iapetus and Phoebe. On disk-integrated spectra is in general very difficult to recognize more spectral features that become more evident on restricted regions observed at high spatial resolution. For the minor moons the following characteristics are derived [3]: in the visible range Atlas, Prometheus, Pandora and Janus have a step red slope for $\lambda<0.55$ µm that become less evident on Epimetheus, Calypso and Telesto. In the 0.55-1.0 µm range both Epimetheus and Janus are slightly red; Atlas, Prometheus and Pandora are almost neutral while Calypso and Telesto are blue. This effect seems to be correlated with the presence of a UV absorber, more abundant on the "red" surfaces. Calypso and Telesto therefore appear quite blue and coated by more pure water ice. In the IR range the main features of the water ice are detected as well: the bands at 1.5, 2.05, 3.0 µm are evident on each satellite. The faint 1.05 and 1.25 µm bands are detected only on Calypso. In some cases is visible the Fresnel peak at 3.1 µm. The low SNR characterizing these observations don't allow to recognize any spectral feature for $\lambda>4$ µm.

Radial distribution of water ice and contaminants in the satellites system

The radial distributions of the surface contaminants (UV absorber agents) and of water ice are shown in Figure 2 for the principal satellites. The distribution of the contaminants is peaked towards the Titan's orbit, being Rhea the reddest object in the 0.35-0.55 µm range and Hyperion in the 0.55-0.95 µm range. The distribution of the water ice abundance, correlated to the 2.0µm band depth, show a linear decrease with the log of the radial distance from Saturn, moving from the inner satellites (Mimas, Enceladus) towards the outer regions of the system (Iapetus, Phoebe). Interestingly, Dione slightly deviates from this general distribution, having a band depth lower respect to the neighbour satellites (Tethys and Rhea). These distributions will allow us to infer the properties of the saturnian system during its formation and evolution.

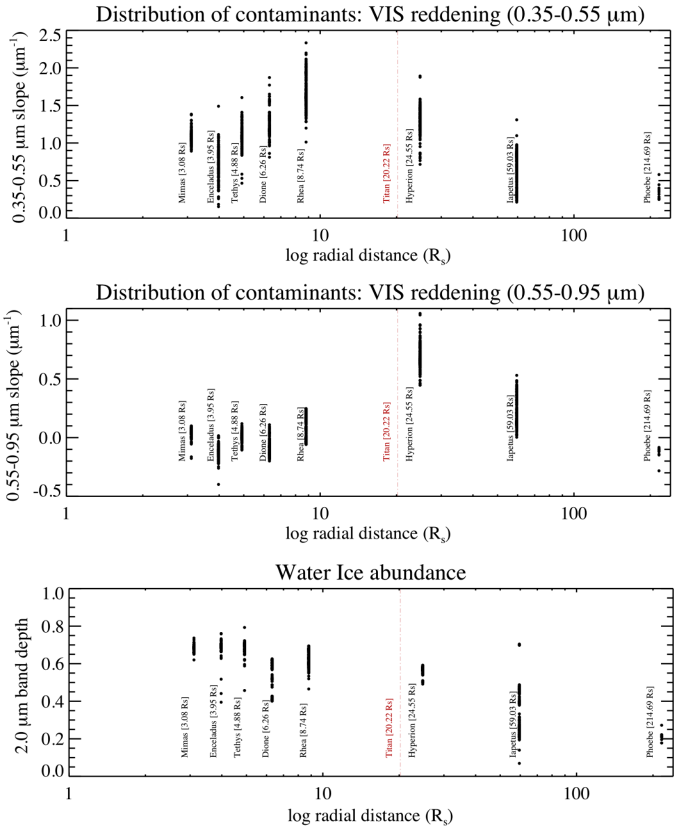

Figure 2: radial distribution of contaminants measured through the VIS reddening in the 0.35-0.55 µm range (top panel) and in the 0.55-0.95 µm range (central panel). Radial distribution of the water ice abundance retrieved from the 2.0 µm band depth (bottom panel).

References

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[3] Filacchione, G. et al. (2009) *LPSC, XL* 1780.