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Constraining the radial distribution of water ice and chromophores across Saturn's rings, regular and minor satellites

G. Filacchione (1), F. Capaccioni (1), M. Ciarniello (1), R. N. Clark (2), P. D. Nicholson (3), D. P. Cruikshank (4), J. N. Cuzzi (4), M. M. Hedman (3), F. Tosi (1), B. J. Buratti (5), P. Cerroni (1), and R. H. Brown (6)

(1) INAF-IAPS, Istituto di Astrofisica e Planetologia Spaziali, Rome, Italy (gianrico.filacchione@inaf.it), (2) USGS, Denver, CO, USA, (3) Cornell University, Ithaca, NY, USA, (4) NASA-AMES, Moffet Field, CA, USA, (5) NASA-JPL, Pasadena, CA, USA, (6) Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ, USA

The main aim of this work is to trace the radial distribution of surface water ice and chromophores across Saturn's rings, regular and minor satellites using Cassini-VIMS (Visual and Infrared Mapping Spectrometer) data. Reflectance spectra of these different objects are analyzed and clustered in spectral classes using specific VIS-IR indicators applied to VIMS datasets. Specifically, we report results from the analysis of about 3,000 disk-integrated observations of the icy satellites and ten rings radial mosaics. Surface compositions and regolith properties are inferred through the comparison with laboratory and synthetic spectra of analogue materials. In both cases, for each target it is essential to process as many observations taken at different illumination conditions as possible, in order to decouple the phase response from spectral analysis. With the exclusion of Phoebe and the dark material coating Iapetus' leading hemisphere, VIMS data demonstrate that the water ice radial distribution, traced using the 1.5-2.0 μm band depths, is almost constant across the entire Saturnian system. This result is an indication of the "alien" nature of Phoebe and Iapetus dark material in Saturn's original population. Chromophores mixed in ice are constrained thanks to their characteristic reddening shown at visible wavelengths. The maximum reddening is measured across the A-B rings and on Rhea and Hyperion. Moreover our analysis allows us to recognize several other specific effects characterizing the Saturnian population, like: 1) the dichotomy between regular satellites leading and trailing hemispheres caused by the accumulation of exogenic material and by interaction with magnetospheric particles; 2) the low reddening seen in the spectra of the satellites orbiting within the E-ring (from Mimas to Tethys) caused by the coating of Enceladus plumes particles; 3) the spectral similarities among Prometheus, Pandora and A-B ring particles point to a possible common origin; 4) the spectral differences between Tethys' lagrangian moons, with Calypso much more water ice-rich than Telesto; 5) the presence of carbon dioxide ice and organics on the three outermost satellites, Hyperion, Iapetus, Phoebe. Such comparative analysis and radial trends could help us to decipher the origins, histories and evolutionary processes of rings and satellites orbiting in Saturn's system.