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Nature of the 2.8-µm window in Titan's atmosphere and effects on detection of surface reflectance characteristics

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Abstract

The surface of Titan is visible in the visual and IR through its thick and scattering atmosphere only within a few narrow windows between strong methane absorptions. One of these windows is near 2.8 µm (Figure 1). Previous studies have shown this methane window to be complex with an unknown absorption within the window, creating two subwindows [1, 2]. This window is critical to studying the surface composition using spectroscopy because several candidate surface materials (e.g., CO_2, H_2O, NH_3) have differing reflectance changes (contrasts) across the window. Reflectance measurements through the subwindows are only partially representative of the surface properties.

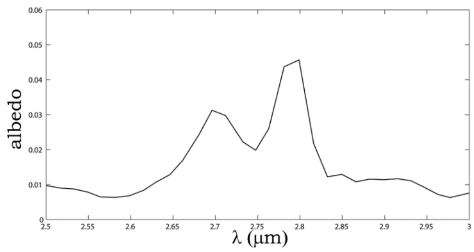

Figure 1: Titan's albedo in the 2.5 – 3.0 µm region from Cassini VIMS measurements. An absorption at 2.75 µm due to an unknown material divides this methane window.

Titan's primary crustal material is likely water ice [2, 3, 4] and nearly pure H_2O ice was reported to be exposed in some regions [5]. Ammonia has been suggested as the brightening agent behind a series of fluctuations in brightness at Hotei Regio and possibly another area in Xanadu [6]. However, the basic composition of this feature and others of Titan's brightest surface units is in question, and both CO_2 [3] and HC_3N [7] are candidates. These arguments depend partly on differences in spectral contrast across the 2.8-µm window from place to place on Titan for each of these suggested materials.

Previous studies have sidestepped difficulties in modelling this spectral region by acknowledging ignorance of the atmospheric opacity and using only relative differences. Relative differences could be meaningful even if the absolute transmission of the subwindows is not known. For example, H_2O has a strong blue slope in this spectral region, in contrast with the apparent albedo of Titan, which nearly everywhere has the opposite slope, with the largest 2.8/2.7-µm contrast at Hotei Regio and Tui Regio [2,3], both putative cryovolcanoes [6, 8]. However, if Titan's atmosphere absorbs more strongly at the short-wavelength side of the 2.8-µm window, the apparent contrast could be the result of a reversal due to methane absorption and/or aerosol scattering. Then, the strong spectral contrast at Tui Regio and Hotei Regio may simply be due to depletion in H_2O ice relative to the rest of Titan.

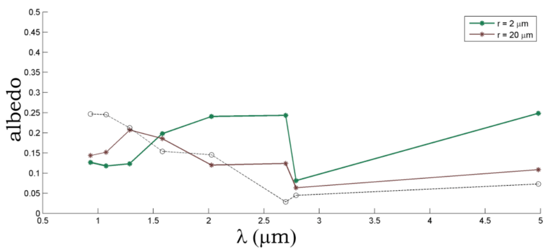

Figure 2: Atmosphere-corrected reflectance of Tui Regio based on a radiative transfer model assuming water ice is exposed in the Fensal-Aztlan region (~ 0°W, 0°N)

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Thus, we have been exploring the nature of this window. There are indications [2] that the unknown absorption within the methane window is mostly or entirely atmospheric because it exists even above the cloud tops, and Titan appears featureless at this wavelength. We are analyzing the Cassini VIMS occultation results using this region of the spectrum. We also developed a radiative transfer model for deriving relative atmospheric transmissivities and surface albedos [6]. Early results (Figure 2) support the conclusion that the 2.75-μm absorption dividing the double window is indeed atmospheric, and that Titan's atmospheric absorption is the cause of the strongly positive 2.8/2.7 μm contrast. Therefore, the areas of Titan most suggestive of recent activity appear to be depleted in water ice and enriched in a more spectrally neutral material, possibly NH_3, HC_3N, or CO_2 ice.

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