SATURN'S TITAN: CASSINI VIMS REPORTS REGIONAL REFLECTANCE CHANGE CONSISTENT WITH SURFACE ACTIVITY

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Introduction: The near-infrared reflectance of a 73,000 km^2 area on Titan changed between July 2004 and March of 2006. The reflectance of the region (latitude 26S, longitude 78W) increased twofold between July 2004 and March-April 2005. It then returned to the July 2004 level by November 2005. By late December 2005 the reflectance had surged upward again to a new maximum. It then declined for the next three months. Detailed analyses indicate that the brightenings are a surface phenomenon, making these the first changes seen on Titan's surface. The spectral differences between the region and its surroundings rule out the ices of H_2O, CO_2, and CH_4 as possible causes. Remarkably, the change is spectrally consistent with the deposition and removal of ammoniated materials. NH_3 has been proposed as a constituent of Titan's interior but not its surface or atmosphere. This transitory NH_3 spectral signature is consistent with occasional effusion events in which juvenile ammonia is brought to the surface. Its decomposition may feed nitrogen to the atmosphere. The size of the region suggests it may exceed the size of the largest active volcanic areas in the solar system.

The Observations: Cassini's VIMS obtains relatively narrowband ($\Delta\lambda$=0.014 µm) images of Titan at 352 wavelengths between 0.4-5.2 µm[1]. VIMS is able to observe Titan's surface and atmospheric clouds through windows at 0.93, 1.08, 1.27, 1.59, 2.02, 2.69, 2.79, and 4.98 µm where CH_4, the main atmospheric absorber, is most transmitting. In eight instances the difference in reflectance (I/F) of the region and average I/F a set of surrounding reference points was measured. The average i and e of the reference points closely approximated the i and e of the region (Fig 1). This permitted us to establish the relative change in the regions's brightness in the methane windows over the entire series of observations.

Fig 2 shows the difference between the I/F of the region and that of the control point average.from Jul04 to Mar06. The reflectance of the region is higher relative to the surroundings on Mar-Apr 2005 and Dec 2005.

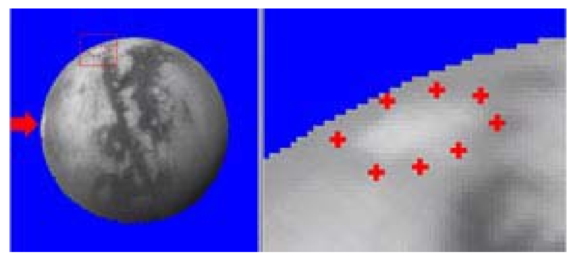

Fig. 1. Left -VIMS composite image at 2.02 µm for the 25Dec05 flyby (N is to the left) . Right-Enlargement of area enclosed by the red box on left. A cloud is indicated (red arrow).

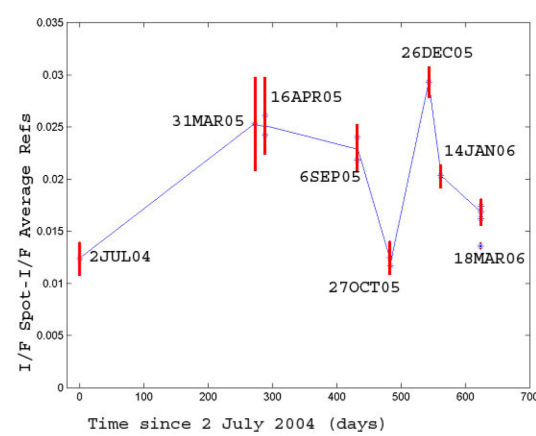

Fig. 2 Reflectance change at 2.02 µm Jul 04-Mar 06

Interpretation: We dismissed the possibility that this change could be caused by variable cloud coverage. Tropospheric clouds are distinguished in three-color images at wavelengths where methane is opaque, where it is partially transmitting, and at the center of the 2 µm CH_4 band where it is most transmitting[2]. This technique is shown in Fig. 3 where the cloud (blue arrow) stands out as blue. Our region of interest (green arrow) does not. Also, radiative transfer analysis using methane gas transmission coefficients at Titan's temperature and pressure conditions[3] finds no elevation of the region greater than 2 km.

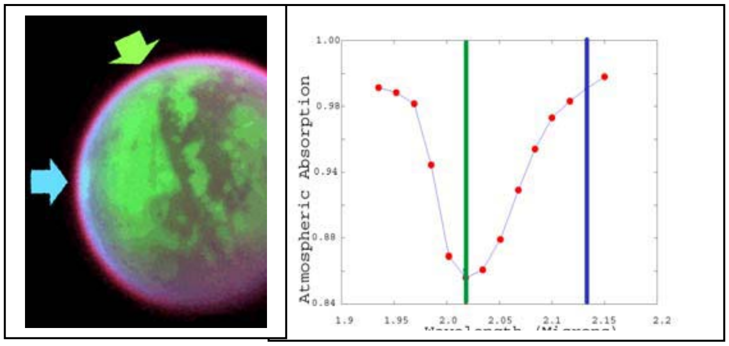

Fig 3. Left-RGB image of Fig 1. G (2.02 μm) is at the center of the methane window. B (2.13 μm) is at the band wing and shows the elevated cloud. R is 2.4 μm where CH_4 is completely opaque. Right- Titan's spectrum, 1.94-2.16 μm

We examined spectra of the region at the epochs where its reflectance was high. We ratioed the average of these to the average spectra of the region at epochs where the reflectance was low (Fig. 4a,b). This ratio technique is approximate. It does not completely remove the effect of methane and haze absorption in Titan's atmosphere as is evident from the inverse expression of the methane bands in the methane windows. The approximate limits of the windows at the 50% transmission level is shown by cyan shading. Nevertheless, spectral features of NH_3 frost (shown as the magenta line in Fig. 4a,b), albeit somewhat distorted in shape, are seen in the ratio spectra.

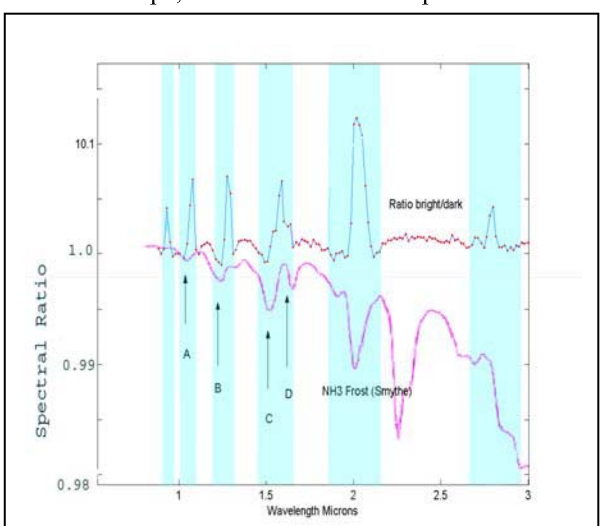

Fig 4 a. The NH_3 frost features are seen in the ratio at A=1.05 μm, B=1.24 μm, C=1.52 μm, and D=1.65 μm.

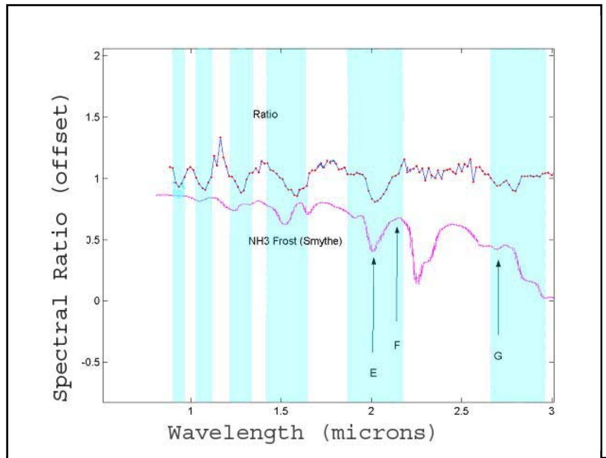

Fig4b. The ratio is divided by the normalized spectrum of the background to effect different amount of methane haze correction. This displays the NH_3 absorption features E=2.01 μm , F=2.13 μm , and G=2.69 μm.

The distortion in shape is not unexpected given that the centers of the NH_3 absorption features do not exactly coincide with the centers of the methane window transparency. The spectral change we observe is inconsistent with laboratory spectra of frosts of H_2O, CO_2, and CH_4[4] It is consistent with NH_3.

Discussion: NH_3 is expected to be found in Titan's interior[5]. The changes we report suggest geologic activity has occurred on Titan between 2004 and mid to late 2005, the evidence of which is was slowly weathered, evaporated, chemically decomposed, or covered over. The changing area is twice the size of the big island of Hawaii and comparable to Io's Loki. It may be the largest active area in the solar system.

Titan may now join Earth, Io, Triton, Enceladus, probably Venus, and possibly Europa as the small community of planetary objects in the solar system that exhibit active surface processes. Pre Cassini, Titan was thought of as a pre-biotic earth that was frozen in time. Instead we suggest that the current Titan is a snapshot of a rapidly evolving object. The participation of two species (CH_4 and NH_3), important molecules associated with pre-biological chemistry, as active components of Titan's geologic process is of more than passing significance. The chemical processes happening on or withinTitan today may be similar to those under which life evolved on earth .

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