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Observations of Titan's haze and clouds by Cassini VIMS

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Abstract

The study describes recent observations of Titan's atmosphere by the Visual and Infrared Mapping Spectrometer (VIMS) onboard the Cassini spacecraft. These observations include solar occultation observations, observations of North polar clouds and specular reflections on Titan's seas. The goal is to determine the optical depth of Titan's haze as a function of wavelength, latitude and season, and to better constrain the organic cycle.

1. Introduction

Titan is the only satellite in the solar system with a dense atmosphere with methane constituting the second largest component. Methane is irreversibly transformed into ethane by photolysis. The carbon cycle includes the replenishment of the atmosphere with methane [1,2], the formation of clouds, the precipitations of methane and ethane, the formation of organic molecules in the upper atmosphere, their coalescence to form the haze particles [3], the sedimentation of those heavy organic molecules that are eventually swept by surface winds to form the dunes [4], the formation of lakes at polar latitudes [5] and the interaction of liquid hydrocarbons with the icy porous regolith [2,5]. Since Titan entered spring, the VIMS instrument has observed the formation of clouds forming on the North Pole (Fig. 1). Specular reflections on the large seas provide information on the waves and winds [6]. Finally, solar occultation observations provide constraints on the haze opacity on the North Pole and can be compared with previous solar occultation observations at other latitudes.

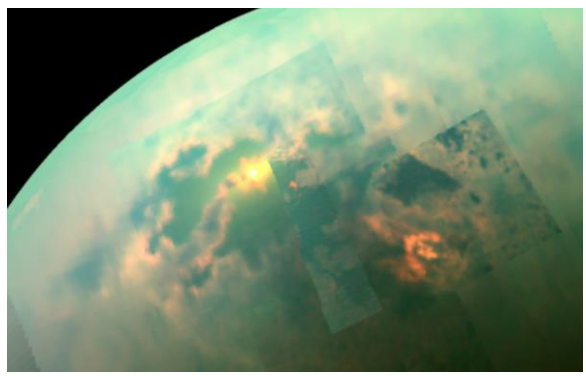

Figure 1: Titan flyby T104 showing a cloud (V shape) over Ligeia Mare, specular reflection on Kraken Mare (large yellow spot), and 5-µm bright shorelines along Kraken Mare.

2. Solar occultation observations

During flyby T103 in July 2014, the VIMS instrument recorded solar light curves through Titan's atmosphere for an impact parameter located at 66S and 55N during ingress and egress, respectively. These observations complement previous observations obtained at different latitudes since the T10 observations obtained in January 2006 [7]. These new observations show that the opacity at the polar caps is less that the opacity at the equator (Fig. 2).

At shorter wavelengths (0.9- to 1.6-µm), the VIMS values and the DISR values [3] are in very good agreement. However, the extrapolation of the DISR trend to longer wavelengths predicts larger opacities that the values inferred from the VIMS observations.

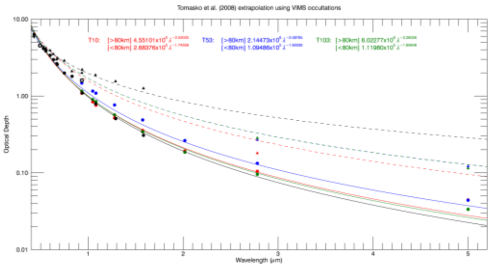

Figure 2: Comparison of the opacities obtained by the Huygens probe [3] and the VIMS instrument.

3. Clouds

Few clouds have been observed on the North Pole although their formation due to the evaporation of methane from the lakes was predicted by Global Circulation Models [8]. However, during the T104 flyby (Fig. 1), the VIMS instrument recorded a large V-shape cloud over Ligeia Mare. The characteristics of this cloud are being investigated to determine its origin.

4. Specular reflections

The VIMS instrument has acquired several observations of specular reflections on the large seas present on Titan's North Pole such as the one detected during T104 (Fig. 1). Besides providing information on the roughness of Titan's surface (waves), these observations also provide spectra that can be used to infer the opacity of Titan's atmosphere and to compare with the values obtained by the solar occultation observations [9].

5. Spectral information

The spectra of the clouds, the specular reflections, the solar occultation observations can be compared with spectra of the surface. Of particular interest are the absorption features in the two broad atmospheric windows at 2.7- and 5-µm. Three absorption features can be identified in the 2.7-µm window at 2.57-, 2.74-, and 2.97-µm. The 2570 nm feature is present in the specular reflection spectra, the surface spectrum and the solar occultation observations and is a methane band. The 2740 nm feature is present in the surface spectrum, slightly visible in the T110 specular reflection observation and almost invisible in the T84 specular reflection. It is also not visible in the solar occultation observation. It is therefore interpreted as a surface feature. There is debate onto whether this absorption could be related to the presence of water ice at the surface. However, water ice remains dark at higher wavelengths, which is clearly not the case of the surface spectrum. Finally, the 2970 nm feature is visible in the surface spectrum and the specular reflection observations but not in the solar occultation observations

5. Summary

The diversity of the VIMS observations provide important information that help understand Titan's organic cycle. The good agreement between the DISR observations and the VIMS observations gives confidence in the retrieved opacity of the atmosphere. This is important for radiative transfer models that are used to retrieve the surface albedo.

Acknowledgements

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