EPSC Abstracts
Vol. 6, EPSC-DPS2011-1659, 2011
EPSC-DPS Joint Meeting 2011


# Aerosol distribution and physical properties in the Titan atmosphere

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## Abstract

Aerosols appear to be the primary component determining the properties of the Titan atmosphere. Observations using the Cassini UVIS spectrographs have provided measurements the aerosols in two related phenomena. The presence of these particles is found in occultation extinction spectra, and in emission spectra showing the distinctive characteristics of scattered solar radiation. The relationship between extinction properties and radiation scattering provides information on the particle physical properties. A calculation at high altitude provides simple single scattering considerations. The Titan encounter on 2004 DOY 184 provided observations above the sub solar region at solar phase ~ 90 deg. Combined accumulated stellar occultation and emission measurements allow calculation of a Mie theory particle radius of 76A using tholin index of refraction properties[1]. The mixing ratio is estimated at $10^{-6}$ at 1030 km altitude.

## 1. Introduction

Occultation measurements of the Titan atmosphere using the Cassini UVIS experiment have allowed extraction of extinction optical depth by aerosols in the altitude range 300 to 1000 km [2]. The aerosol extinction spectra in the FUV between 1550A and 1950A follow the imaginary part of the refractive index for tholins defined from the laboratory experiments by [1]. The extinction measurements provide optical depth profiles of the aerosols but the abundances cannot be determined without specific knowledge of the particle absorption and scattering properties. In principle this can be done entirely by using multiple UVIS spectrograph measurements of emission properties over a range of solar phase angles and impact parameter (IP) altitudes. At the present time an insufficient number of observations have been reduced to carry out an analysis of this kind. In order to move the investigation forward, an approach using the compatibility of the extinction shape function with the Khare et al. 1984 [1] results has been carried out with the high altitude observation mentioned above.

## 2. Methodology

The determination of the aerosol vertical abundance distribution is obtained from stellar occultations. The measurements given the unknown cross section magnitude uses a nominal normalization value to derive a distribution. Figure 1 shows the profiles obtained from two stellar occultations compared to the $CH_4$ profile. Profiles are known to vary in magnitude depending on latitude and probably with season.

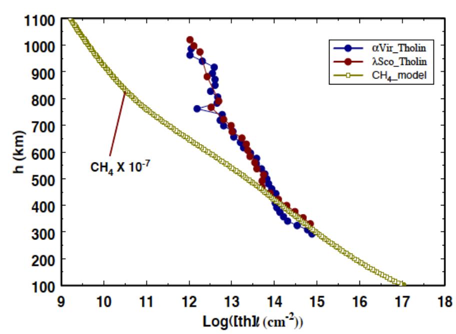


Figure 1: Profiles of aerosol abundance from two Titan TB occultations compared to the scaled $CH_4$ profile.

The scale heights of the aerosol distribution above 400 km altitude are roughly 130 km compared to 48 km for the $CH_4$ profile for the region below diffusive separation. The scale height for the aerosols is therefore not representative of a hydrostatic equilibrium condition, and indicates that the aerosols are produced at high altitude and diffuse downward to below 450 km before mixing with the majority gas to conform to the $N_2$ and $CH_4$ profiles.

Figure 2 shows an emission spectrum obtained by the same UVIS spectrograph in airglow mode on 2004 DOY 184 at an IP of 1030 km. The data is shown superposed with electron excited $N_2$ LBH and NI models that account for most of the emission with the exception of the long wavelength region which is accounted for by solar reflection by the aerosol particles. A model of the solar reflection is shown as the light blue curve, using an albedo designed to fit the profile. Structure in the reflection model is caused by the inclusion of hydrocarbon extinction imposed on the passage of the solar radiation through the atmosphere in the line-of-sight (los) of the spectrograph.

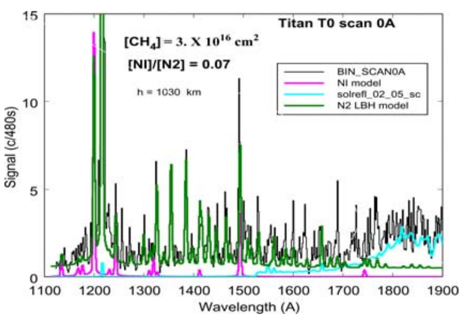


Figure 2: The UVIS fuv spectrum obtained 2004 DOY 184 at los IP 1030 km showing the presence of electron excited $N_2$ LBH and NI features and solar reflection by aerosols in the long wavelength region.

## 3. Results

The brightness of the solar reflection at 1826A in Fugure 2 is 1.3 R/A. This corresponds to an albedo of $4.9 \times 10^{-3}$. Using Mie scattering theory and the tholin complex refractive index from [1] this establishes a scattering particle radius of 76A. The density of these tholin particles is derived to be 3870 $cm^{-3}$. The mixing ratio is determined to be $10^{-6}$ at the IP of 1030 km.

## 4. Summary and Conclusions

It has been found in examining the inferred albedo properties (Figure 2) that the spectral profile of the albedo curve significantly deviates from a Rayleigh scattering wavelength dependence. One possible explanation is a non uniform wavelength dependent scattering phase function. This issue will be explored by examining more observation geometries.

The aerosol profiles are certainly not globally uniform, with apparent high altitude production concentrated at low latitudes. Over the poles, solar scattering is not detected above 700 km, implying that the main source is at low latitudes, stimulated by the plasma-sheet combined with solar radiation. Recent work [3,4] discusses the detection of heavy ions in the high atmosphere, suggesting ion chemistry could be the primary source of the aerosols. These issues will be discussed in the presentation.

## Acknowledgements

This work was carried out at Space Environment Technologies (PSSD) and California Institute of Technology (CIT). Support is provided by the Cassini UVIS program at the University of Colorado (LASP). Student grant support is provided in the CIT program .

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