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Retrieving the aerosol particle distribution in Titan's detached layer from ISS limb observations

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Abstract

The study of the detached haze layer above Titan's thick atmosphere is one of the key elements to understand the growth of the aerosols in the upper atmosphere of Titan. In this work we will present the results of a radiative transfer inversion of the vertical profile distribution of aerosols in the detached haze layer (from 300 to 600 km) by using the I/F ratio observed by Cassini ISS camera. The analyses will focus on the derivation of the particle size distribution.

1. Introduction

Titan's atmospheric detached haze layer was first observed in 1983 by Rages and Pollack [1] during the Voyager 2 exploration with the first full coverage of Titan's atmosphere at intermediate and high phase angles. The analyses of these images showed the presence of an aerosol opaque thick layer between 300 and 350 km over the main haze of Titan. Since 2005, the Imaging Science Subsystem (ISS) instrument on board the Cassini mission performs a continuous survey of the Titan's atmosphere almost every month. In 2011, West *et al.* [2] confirm the persistence in time of the detached haze layer but with an important variability in its height (over 500 km in 2007, under 380 km in 2010). Detail analyses showed, that this layer corresponds to the transition area between small spherical aerosols and large fractal aggregates [3, 4]. Then, the characterization of the aerosols' size distribution along vertical profiles in the detached haze layer is one of the key elements to understand their growth.

2. Observations

In this study, we focus our analysis on the I/F ratio observed by ISS at the limb of Titan for different phase angles. We have restricted the observations on the detached haze layer most probable location between 600 km to 300 km, in the UV filter ($\lambda = 338$ nm, where the multiple scattering is low) and in a short period of time (2006).

Table 1: List of ISS images used in CL1-UV3 filter

ISS ID	Date	Phase	Sun lat.
N1525327324	2006/04/03	146.9 °	-32.9 °N
N1540314950	2006/10/23	120.2 °	-1.9 °N
N1521213736	2006/03/16	68.0 °	-19.3 °N
N1546223487	2006/12/31	66.5 °	-5.9 °N

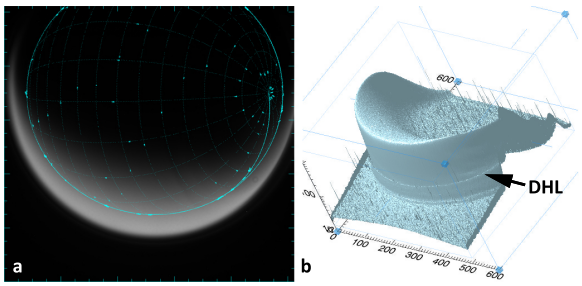

Figure 1: (a) ISS image N1540314950 with its coordinates grid. (b) 3D plot of I/F ratio to see the detached haze layer.

3. Model

Considering the atmosphere of Titan homogeneous longitudinally, we use the vertical profile according from HASI' measurements [5] for the temperature, the pressure and the density. Then, we modeled the effect of the Rayleigh scattering, the gas absorption [6] and the spherical/fractal aggregate aerosols [3] opacity. We calculate I/F at the limb, assuming a spherical geometry [1]:

$$\frac{I_n}{F} = \sum_{i=1}^{2n} \int_{z_{i-1}}^{z_i} \frac{\langle \omega_0 P(\theta) \rangle_j}{4} \exp\left(-\tau_{0i}(z) - \tau_i(z)\right) \beta_j \mathrm{d}z \tag{1}$$

With $\langle \omega_0 P(\theta) \rangle_j$ the product of the single scattering albedo and the phase function for scattering angle of $\theta = 180 - \phi$, and β_j the extinction coefficient in the layer j.

Therefore, the aerosol size distributions are constrained layer by layer from the top to the bottom of the detached haze layer. The inversion is performed by a Levenberg-Marquardt algorithm (provided by More *et al.* [7] in the *minpack.f90* package)

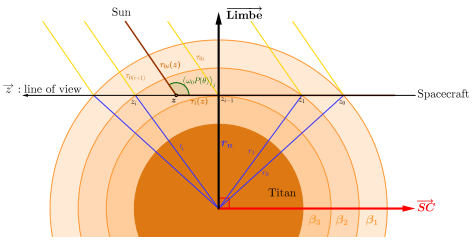

Figure 2: Integration of the light along the line of sight in a spherical atmosphere with the onion peeling method.

4. Perspectives

Analyses of Cassini ISS observations with the use of the model will provide a temporal survey of the evolution of the detached haze layer in term of aerosol distributions in height and in radius. We will also be able to constrain the latitudinal variations between the equator and the poles. The next development of this model will take into account the multiple scattering to perform the inversion on the whole profile at different wavelengths to apply it to the other filters of ISS and VIMS.

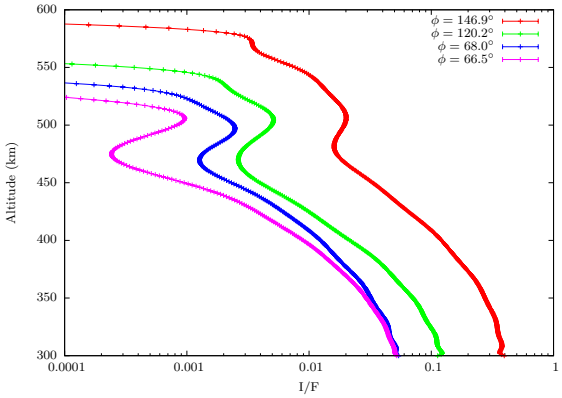

Figure 3: Observations of the I/F ratio profile for different phase angles at the geographic equator (0 to 5°N).

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