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Aerosols in Titan detached haze layer

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Abstract

Titan, the largest moon of Saturn, has a dense atmosphere of about 1.4 bar composed of 98% of nitrogen, 1.4 to 5% of methane and a wide variety of organic trace species produced by a complex photochemistry. Some of these species polymerize to form several haze layers. The most remarkable feature is a global detached haze layer around 510 km, which dropped by 150 km at the equinox. Up to now, the exact origin and nature of this haze is under a vigourous debate. In this work we investigated the origin and nature of this haze and we studied the aerosols with respect to the latitude.

1. Data and Methods

1.1 Data

To characterize the detached haze layer, we used large phase angle images acquired by Cassini probe with the ISS camera at different dates between 2005 and 2009, at seven different phase angles (from 112° to 161°) and with two different filters. Each image is calibrated in radiance factor (I/F, where I is intensity and πF is the incident solar flux) and geo-referenced. In the part of this work about origin and nature, we have averaged I/F over the range 30°N – 20°S for the UV3 filter (ultraviolet filter, λ = 338 nm) and over the range 40°N – 10°S for the BL1 filter (blue filter λ = 460 nm). For the study with respect to the latitude, we have taken I/F at latitudes in the range 60°S – 30°N for both filters. For each wavelength and each phase angle, we used the maximum I/F value in the detached haze layer at about 500 km altitude. To perform the analysis, we assumed that the altitude (500 km) and the number of particles do not vary in the detached haze layer between 2005 and 2009 [1]. To gain information, we considered the tangential opacity at 514 km observed by UVIS stellar and solar occultation in the range 150-190 nm [2].

1.2 Methods

To model the scattering of the detached haze layer we used a spherical shell model. We computed first the single scattered intensity for phase angle by a ray tracing model. Then we corrected for the multiple scattering with a scaling factor. This scaling factor was computed with the SHDOMPP radiative transfer solver [3]. Then the radiance factor I/F was computed. In the detached haze layer, the aerosols are distributed in size. Thus, we used a 2-exponent and a 1-exponent law to represented the distribution.
The parameters of the distribution laws were fitted to give the best fit between the observed and the computed I/F. The fit was controlled by a χ^2 test.

2. Results

In the part of this work about the origin, we show that the detached haze layer is composed of a mixture of small nanometric macromolecules (80% in mass), directly produced by photochemical processes in the mesosphere, and large aggregated aerosols (producing more than 90% of the scattering) brought from below by winds. Interaction with winds also explains the temperature gradient at the same altitude. The study shows that the exponents in the 2-exponent law are equal within the error bars. Thus, a 1-exponent law is allowed for the size distribution.

This single power law was used to study the aerosols with respect to the latitude. The first results show that the mean radius of the aerosols slightly increases from the southern latitudes to the northern latitudes. In the same way, the exponent of the distribution law slightly changes from south to north.

3. Figures

The figures below show an example of I/F vertical profiles coming from the ISS data and results on I/F

with respect to the phase angle obtained with the best fit.

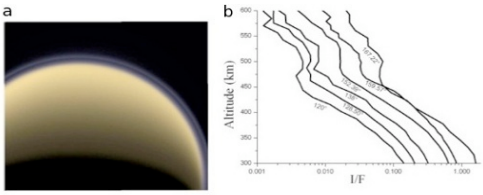

Figure 1

Figure 1: Left panel: Image in false color of Titan made by ISS at visible wavelengths. The detached haze layer appears in violet above the main haze layer. Right panel: Center-to-limb radiance factor (I/F) profiles taken from ISS images in the BL1 filter, for some phase.

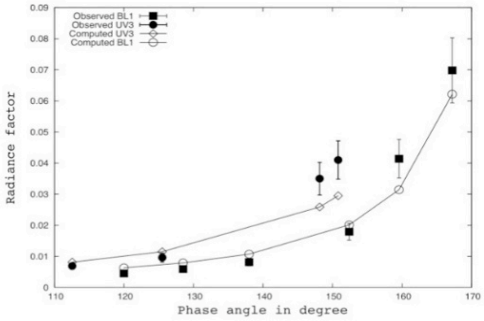

Figure 2

Figure 2: Observed and computed radiance factors at the maximum of the detached haze layer as a function of the phase angle, for the two filters (UV3 and BL1). The computed radiance factors correspond to the properties obtained by fitting ISS and UVIS simultaneously with the 2-exponent law size distribution.

References

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