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Vertical distribution of gases and aerosols in Titan's atmosphere observed by VIMS/Cassini solar occultations

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Abstract

We will present the vertical distribution of gaseous species (CH4, CO) and aerosols in Titan's atmosphere through the analysis of VIMS solar occultations. VIMS can provide good vertical resolution (~15 km) and an extended altitude range (from 70 to 700 km), complementing well the information from other Cassini instruments. Thanks to the spread of VIMS solar occultations through the whole Cassini mission we will also be able to show the seasonal variations of the aerosols' vertical properties.

1. Introduction

Knowledge of the vertical characteristics of Titan's atmosphere has greatly improved since the deployment of the Cassini mission. In-situ profiles of climatological parameters [2] and the main atmospheric species [4] were obtained from the Huygens descent probe. Further information is obtained by the Cassini orbiter, which is routinely monitoring the vertical abundances of various gases and aerosols with the CIRS and UVIS spectrometers [3,5,6]. In this framework, additional information is provided by the VIMS imaging spectrometer, which probes the vertical structure of the atmosphere by means of the occultation technique in a complementary wavelength range with respect to the other Cassini instruments.

2. The VIMS solar occultations

Occultations are a powerful tool to study the vertical properties of planetary atmospheres. During an occultation a source of light (the Sun for solar occultations) is observed at different limb altitudes with and without the atmosphere along the line-of-sight. The atmospheric transmittance at the different altitudes is then retrieved by dividing each spectrum for a reference obtained outside the atmosphere. This self-calibration removes the uncertainties connected to the instrumental transfer function of the spectrometer and, because a reference spectrum is extracted at each observation, occultations are insensitive to instrumental aging.

Solar occultation observations are acquired through the solar port. We employ here the infrared channel, which covers the 1 – 5 µm wavelength range. During occultations, one spectrum per hyperspectral image is extracted for each probed altitude. The signal-to-noise ratio decreases with wavelength, and depends mainly on the strength of the solar signal. VIMS' vertical resolution depends on the integration time and is typically 15 km, below the scale height of Titan's atmosphere. Figure 1 shows an example of VIMS spectrum in the atmosphere. The transmittance is affected by the presence of aerosols and gaseous species along the line-of-sight.

One key feature is the pointing stability. If the image of the Sun in the detector fluctuates during an occultation, the shift can generate a spurious fluctuation in the total solar flux. This fluctuation is superimposed to the transmittance variations due to the atmosphere. It also affects the extraction of the spectra. The method employed to correct the pointing uncertainty and to extract the spectra will be approached in the presentation.

3. Analysis of VIMS results

VIMS has retrieved 8 solar occultations up to now. They are distributed through the whole Cassini mission and they probe different latitudes in both hemispheres (Fig. 2). The first of these occultations was analyzed by [1].

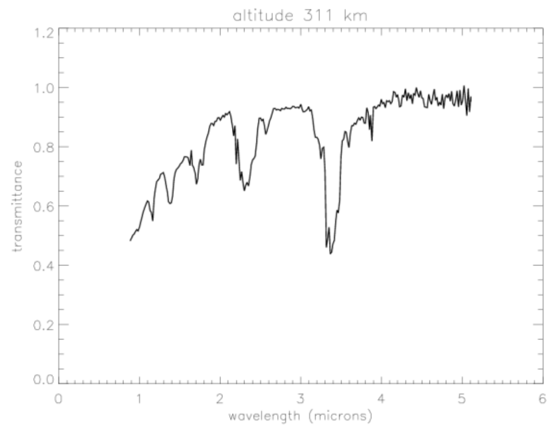

Figure 1: VIMS transmittance spectrum obtained at 311 km altitude during the first occultation (T10) of the instrument. We can notice the extinction due to the aerosols, which affects mainly the wavelengths λ < 2 µm at this altitude, and the methane bands at 1.2, 1.4, 1.7, 2.3 and 3.3 µm. The 3.4 µm CH4 band is blended with another band that has been attributed to aerosols [1].

Two main gases can be observed by VIMS occultations: methane, through its bands at 1.2, 1.4, 1.7, 2.3 and 3.3 µm, and CO, at 4.7 µm. We can extract methane's abundance between 70 and 700 km and CO's between 70 and 180 km. We will present the derived vertical distributions.

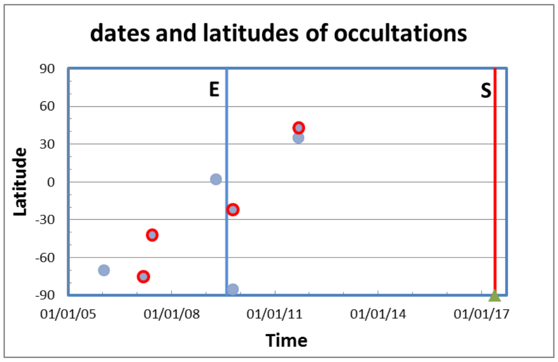

Figure 2: position of retrieved solar occultations. Red circles indicate ingress and blue dots egress observations. The vertical blue line marks the position of the vernal equinox (E) and the red line the summer solstice (S).

We will also show the vertical variations of aerosols' properties in the atmospheric windows. By fitting the spectral dependence of aerosol extinction, we will infer information on their effective size and composition as a function of altitude. The VIMS altitude range will allow us to get information on the properties of both the main haze and the detached layer. Aerosols also affect the transmittance through their spectral signatures. In particular, [1] discovered a spectral signature at 3.4 µm that was attributed to aerosols. We will monitor the latitudinal and temporal variations of these properties through various occultations. A variation in the global circulation regime of Titan sets in with the approaching to the vernal equinox. This change is expected to affect aerosols distribution and properties. A strong decrease in the altitude of the detached layer between the winter solstice and the equinox has indeed been observed [7]. Future observations during the Cassini Solstice Mission will allow us to monitor the seasonal change in the optical and spectral properties of the aerosols with altitude.

References

[1] Bellucci, A., Sicardy, B., Drossart, P., et al.: Titan solar occultation observed by Cassini/VIMS: gas absorption and constraints on aerosol composition, Icarus, Vol. 201, p. 198, 2009.

[2] Fulchignoni, M., Ferri, F., Angrilli, F., et al.: In situ measurements of the physical characteristics of Titan's environment, Nature, Vol. 438, p. 785, 2005.

[3] Koskinen, T.T., Yelle, R.V., Abu-Zayyad, T., et al.: The mesosphere and lower thermosphere of Titan revealed by Cassini/UVIS stellar occultations, Icarus, Vol. 216, p. 507, 2011.

[4] Niemann, H. B., Atreya, S. K., Bauer, S. J, et al.: The abundances of constituents of Titan's atmosphere from the GCMS instrument on the Huygens probe, Nature, Vol. 438, p. 779, 2005.

[5] Vinatier, S., Bézard, B., Nixon, C.A., et al., Analysis of Cassini/CIRS limb spectra of Titan acquired during the nominal mission. I. Hydrocarbons, nitriles and CO_2 vertical mixing ratio profiles, Icarus, Vol. 205, p. 559, 2010.

[6] Vinatier, S., Bézard, B., de Kok, R., et al., Analysis of Cassini/CIRS limb spectra of Titan acquired during the nominal mission II: Aerosol extinction profiles in the 600-1420 cm^{-1} spectral range, Vol. 210, p. 852, 2010.

[7] West, R.A., Balloch, J., Dumont, P., et al., The evolution of Titan's detached haze layer near equinox in 2009, Geophys. Res. Lett., Vol. 38, L06204, 2011.