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A visible solar occultation of Titan's atmosphere from Cassini-VIMS

Emiliano D'Aversa (1), Maria Luisa Moriconi (2), Jean-Christophe Loison (3), Michel Dobrijevic (4), Fabrizio Oliva (1), and Giuseppe Sindoni (1)

(1) IAPS-INAF, Istituto di Astrofisica e Planetologia Spaziali, Rome, Italy (emiliano.daversa@iaps.inaf.it), (2) CNR-ISAC, Rome, Italy, (3) Institut des Sciences Moléculaires,Univ.Bordeaux,CNRS,Talence,France, (4) Laboratoire d'Astrophysique de Bordeaux,Univ.Bordeaux,CNRS,Pessac,France

The VIMS (Visible and Infrared Mapping Spectrometer) instrument on board Cassini spacecraft was able to acquire several stellar and solar occultation measurements of Titan's atmosphere through the mission. VIMS is composed by two separate spectrometers (IR and V channels) covering wavelengths from 0.8 to 5.1 microns and from 0.35 to 1.05 micron respectively. Almost all the aforementioned occultation sequences involved the IR channel, keeping V channel off (see e.g. [1],[2]). In only one case VIMS-V acquired data during a Titan solar occultation and we will report here about the analysis of this data set.

This sequence consists of 210 data cubes composed of 32 samples x 32 lines x 96 spectral bins, acquired through the solar entrance port of the VIS channel. The inbound phase of the occultation was registered, hence the Sun gradually disappears with time behind Titan's limb. Although the projected size of the Sun's disk is much smaller than the VIMS 0.5 mrad pixel, the solar signal during occultation is spread over the images mainly because of atmospheric scattering. Hence, a set of 96 occultation light curves, one for each of the 7 nm wide VIMS-V spectral bin, was obtained, by spatial integration over the full field of view. In the extracted light curves four phases can be clearly distinguished at nearly all wavelengths: 1) high constant level, 2) exponential drop, 3) short ledge at low level, 4) polynomial increase. These phases can be interpreted as 1) unocculted solar signal, 2) gas/haze extinction proportional to the atmosphere density, 3) extinction saturation due to thick aerosols layers, 4) solar forward and multiple scattering from dayside atmosphere becoming predominant.

The phase 1) data allows estimating the unocculted solar signal average level and its fluctuations, useful to directly calculate the atmospheric transmission profiles. No radiometric calibration is needed in this process, reducing the uncertainties and biases related to it.

Geometric calibration is indeed fundamental for associating observing times and tangent altitudes for each spectrum. This has been done by means of algorithms based on JPL NAIF SPICE library and kernels [3]. In doing so, large negative tangent altitudes have been obtained for significant signal levels, demonstrating that light bending due to atmospheric refraction plays a key role in determining the actual line of sight of the observations. More accurate values for tangent altitude have been obtained by means of a raytracing method applied to a spherical shell model filled with N_2 gas with a predefined vertical profile.

Given the high SNR typical of solar occultation measurements, the extracted spectra are suitable to search for previously undetected spectral signatures of both gases and aerosols, as well as retrieve aerosols scattering properties at different altitudes and evaluate the validity range of the most used multiple scattering approximations.

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References- [1] Bellucci,A. et al.2009,Icarus,201,198. [2] Maltagliati,L. et al.2015,Icarus,248,1. [3] Acton, C.H.,1996,Planet.and Sp.Sci.,44,65.