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Uncovering Titan's Surface Spectrum by Modelling Cassini/VIMS and Earth-Based near-Infrared Spectro-Images

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The presence of a methane cycle within the atmosphere of Titan is nowadays well established but poorly understood. Arrived in the Saturnian system in 2004, the Cassini-Huygens mission may help us to constrain this phenomenon by studying processes such as surface reservoirs, circulation and meteorology. The Visual and Infrared Mapping Spectrometer (VIMS [Brown et al 2003]) aboard the Cassini orbiter is one of the tools we can use to recover both images of the clouds and hints about the surface features in terms of morphology and chemical composition through in situ spectro-imaging measurements. These data are complemented by various observational campaigns orchestrated from the Earth by means of Adaptive Optics: for example, in January 2005 at the time of the Huygens probe landing, we acquired in particular several spectra of Titan at the VLT with the NACO instrument; our spectral resolution was higher than the one of VIMS, and we could spatially resolve 21 different regions along Titan's diameter [Negrão et al 2007].

One problem we face in such retrievals is caused by the absorption and scattering of the solar light by the atmospheric CH4 and aerosols. The presence of "windows" of low CH4 absorption allows us to probe down to the surface, yet the scattering by the aerosols and the remnant absorption by the CH4 must be corrected. In this kind of work, we use a multi-stream radiative transfer model based on [Rannou et al 2003], an updated version of the McKay et al (1989) one, taking into account the microphysical evolution of the fractal aerosols. After correction of this atmospheric contribution, we can deduce Titan's surface spectrum, by inversion of the I/F reflectivity.

We compare in this recent analysis Titan spectra calculated with a new methane linelist [Wang et al 2011] and with the various other databases available. Up to now, modellers could only use either band models [Irwin et al 2006, Karkoschka & Tomasko 2010], or more recently transmittance models derived from the Huygens DISR measurements [Karkoschka & Tomasko 2010, Tomasko et al 2008], or a theoretical line compilation [Boudon et al 2006]. Although the VIMS infrared range covers the whole interval 0.8-5.1 μm, we focus first on the 1.58-μm window [deBergh et al 2011], where the new linelist for CH4 is available, and show the discrepancies in the spectra calculated from the various methane databases. We show that the interpretation of the spectra in terms of e.g. surface albedo or haze properties depends on the database used and is much improved by the new experimental data available. This points to the need for new and precise information on the methane absorption in Titan's atmosphere in all near-infrared windows, as in the case of the 1.58-μm window [Wang et al 2011].