Titan’s surface mapping with VIMS/Cassini thanks to coupled atmospheric empirical correction and radiative transfer modeling

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Introduction

Titan is the only large moon in the solar system known to possess an extended, dense and hazy atmosphere. Investigating the composition of the surface and the nature of the surface-atmosphere interactions is thus critical to understand the evolution of this icy moon and its atmosphere.

The Visual and Infrared Mapping Spectrometer (VIMS) instrument [1] onboard CASSINI acquires datacubes in 352 wavelengths simultaneously between 0.35 and 5.1 μm. It can therefore image Titan’s surface through its dense atmosphere in narrow infrared spectral windows (0.93, 1.08, 1.27, 1.59, 2.03, 2.8 and 5 μm), where atmospheric methane absorptions are the weakest. Apart from these windows, the near-infrared spectrum of Titan is almost entirely obscured by the absorptions by the major atmospheric gases and aerosols scattering. As a consequence, Titan spectra show very little variability and it is very difficult to retrieve the surface only spectra.

Modeling Titan’s infrared spectrum

The radiative transfer model accounts accurately for gas absorption, scattering by the haze and/or the cloud cover and surface reflectance and, when validated with the empirical atmospheric correction, can be in fine implemented in an inversion scheme. We discuss here the possible implications of such a method to constrain Titan’s surface properties.
spectra within the range of the VIMS-IR channel by taking advantage of the single scattering formalism [9] and then multiply them by a corrective factor that accounts for the multiple scattering.

The free parameters in our model are the gas abundances, the haze distribution, and, in spectral regions that probe below the tropopause (in the methane windows and their wings), the cloud distribution and the surface reflectance. An example of Titan’s synthetic spectrum obtained with our model is given in Fig. 1.

**Empirical correction methods**

The additive and multiplicative terms due to the atmospheric aerosols and gases in the signal measured by VIMS can be evaluated using simple hypothesis. For example, we use the assumption that a given area observed with very different viewing geometries during different flyby should be the same after the removal of the atmospheric contribution. The correlation with pure albedo and shading effects in band ratios should be minimum when the additive contribution in each band has been accurately removed.

**Perspectives: mapping Titan’s surface in the infrared**

The goal of our numerical modeling is to reproduce spectral Titan’s atmospheric and surface properties that can be compared with those observed by VIMS and/or deduced from empirical calculations.

While our radiative transfer model is still under testing, it provides some first promising results and a fast computation speed. It can be used to improve the surface cartography: thanks to the characterization of the pure atmospheric reflectance, we can correct VIMS observations of Titan’s atmosphere contribution and construct homogeneous spectral maps of Titan’s surface. It can also improve the determination of the surface reflectivity within the entire atmospheric windows, not only at their center. We therefore plan to retrieve absolute constrains on Titan’s surface composition and thus map the distribution of the main constituents of Titan’s surface. This is critical for addressing fundamental questions on the coupled evolution of Titan's atmosphere and surface.

**References**