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Retrieval of surface spectra in region around Titan's polar lakes

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Abstract

Titan, the largest satellite of Saturn, is surrounded by a very dense atmosphere. The pressure and temperatures allow liquid methane and ethane at the surface. Indeed, the *Cassini/Huygens* mission discovered lakes and seas in the polar regions. The Visual and Infrared Mapping Spectrometer (VIMS) from the Cassini spacecraft took hyperspectral images of Titan. Due to the strong absorption of the methane in the atmosphere, the surface can only be seen in 7 spectral windows centered at 0.93, 1.08, 1.27, 1.59, 2.01, 2.7-2.8 and 5 µm. In this work, we use a radiative transfer model to retrieve the surface albedo of Titan's polar lakes from VIMS spectral images.

1. Introduction

Titan's atmosphere is composed of gases, clouds, and a thick layer of haze. Titan possesses a methane cycle. Like on Earth, there is rain, evaporation, and liquid at the surface. However, the haze surrounding Titan scatters most of the visible light, and the strong absorptions of methane block most of the reflected light on VIMS infrared spectral range. Due to Titan's great distance from the Sun, the light received is weak, so the signal/noise ratio of VIMS data is low. Furthermore, VIMS has a spatial resolution of tens of km. In spite of those disadvantages, the surface geology can be studied in some of VIMS spectral windows. Lakes and seas have been detected on Titan's polar regions by RADAR images. An uncertainty exists about their chemistry : the lakes are estimated to be a mixture of liquid CH_4, C_2H_6 and other minor species, with dissolved N_2, and sedimented aerosols. Thermodynamic and experimental constraints have been established for the composition of Titan's lakes [6], but the ratio is still uncertain. The interest of this study is to better determine the composition of the lakes, seas and shores with an inversion of the surface albedo thank to a radiative transfer (RT) model. As the surface albedo is dependent of the chemical composition, once we have the albedo of the lakes and the areas around, we can compare it to experimental data to determine their compositions[3][6].

2. Objectives of the work

There are traces of evaporites on Titan, especially around the lakes, past and present[1][7][2]. One of the objectives is to study the evaporite albedo with the RT model. First, we retrieve the surface albedo around and on the lakes in order to calibrate the model with a surface albedo assumed to be null [5]. Then, we identify spectral features of the evaporites by detecting eventual differences or variations in the spectra. Finally, we look for particular signatures that could identify the zones around the lakes, like in fig. 1. The lake area is distinct from the circumlacustrine zone.

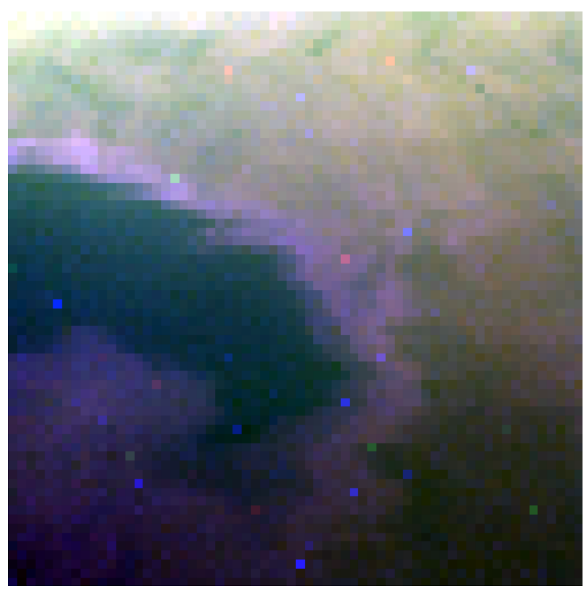

Figure 1: Ontario Lacus, from the VIMS cub V1616820684. RGB channels at 2.03, 1.58 and 2.79 µm. Noise can be seen on the bright-colored pixels.

3. Radiative Transfer Model

The model use the existing solver SHDOMPP developed by K. Evans to solve the RT equations in a plane-parallel approximation. The atmosphere optical properties - such as the single scattering albedo, the phase function, and the optical depth - are determined by using the HASI data for the CH_4 mixing ratio and temperature and pressure profile, Doose's haze extinction coefficient profile, and CIRS data to reproduce the CO, HCN and C_2H_2 vertical profile. We use a correlated-k approximation to calculate the optical depth of the different gases. The spectral rays of the gases (HITRAN database) are used to calculate the absorption coefficients. We used a model of scattering by fractal aggregates to model the haze spectral properties ans we used Tomasko's phase functions, adapted according Doose et al. 2016 suggestions [4][8].

4. Comparisons

Using the VIMS pixel's navigation data, we get the incidence, emission and phase angles that we will use in the model to compare the simulated spectra with the spectra of the different pixels. An error minimization routine makes it possible to fit the surface albedo parameter of the model to the pixel's spectra. In this way, we obtain the surface albedo in the spectral windows. Not all the windows can be used, because some parameters are not well defined and that could be improved in the model. For example the C_2H_6 absorptions are not known. The haze vertical profile is not well defined at high latitudes neither. Once cleared of these uncertainties, the surface albedo obtained can be a reliable source to study the surface composition. In figure 2 the result of the model is close to the data, because the latitude is low, and well corresponds to the haze profile.

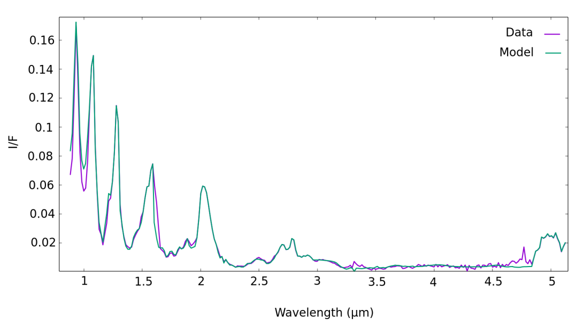

Figure 2: Test of the model, with the pixel (24,34) form the cube C1477457253.

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