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Massive Inversion of Atmospheric and Surface Properties of Titan from VIMS/Cassini Observations

L. Maltagliati (1), S. Rodriguez (1), T. Appéré (1), M. Vincendon (2), S. Douté (3), S. LeMouelic (4), P. Rannou (5), C. Sotin (4,6), J. W. Barnes (7), A. Coustenis (8) and R. Brown (9)

(1) Laboratoire AIM, CEA-Saclay, Gif-sur-Yvette, France, (2) IAS, Orsay, France, (3) IPAG, Grenoble, France, (4) LPG, Nantes, France, (5) GSMA, Reims, France, (6) JPL, Pasadena, US, (7) University of Idaho, Moscow, US, (8) LESIA, Meudon, France, (9) University of Arizona, Tucson, US. (email: luca.maltagliati@cea.fr)

Abstract

We present a method for the massive inversion of VIMS nadir hyperspectral images, which permits the simultaneous retrieval of Titan's surface and atmosphere properties (surface albedo, aerosols opacity) without the heavy computational needs of the full radiative transfer procedures. For the analysis, look-up tables (LUTs) are created by a radiative transfer model based on the k-correlated technique and the SHDOMPP algorithm. The LUTs are then coupled with an ad-hoc inversion procedure to extract the physical parameters from VIMS' datacubes. We will show the first results of the application of this method to selected areas of Titan.

1. Introduction

Since the beginning of the mission in July 2004, Cassini has performed more than 100 flybys of Titan and VIMS has already recorded ~ 40,000 hyperspectral images of the moon, gathering several millions of spectra. Around 30 supplementary flybys will be done until the end of the Cassini mission in 2017. In this framework, the use of classical radiative transfer solvers, such as SHDOMPP or SPSDISORT, to analyze the whole VIMS dataset and extract simultaneously Titan's superficial and atmospheric properties would need an unreasonable time of computation. For this reason, alternative solutions for a massive inversion of VIMS data must be employed.

2. Look-up Tables

Our approach is to apply the full radiative transfer routine SHDOMPP not to the inversion itself, but to create look-up tables (LUTs) for different values of the input parameters (i.e. Fig. 1): geometry of the observation (incidence, emergence and azimuth angles) and physical characteristics (surface albedo, aerosol opacity). After careful consideration, a grid with 12 values of the incidence and emergence angles, 6 values of the azimuth, 10 surface albedos and 10 aerosol opacities has been used to compute the LUTs. The SHDOMPP procedure has been applied within a radiative transfer code based on the correlated-k distribution method [1]. The latest up-to-date spectral coefficients from methane and CH_3D [2,3,4] and haze extinction from DIRS measurements [5] have been employed.

The results from the LUTs are validated through a careful comparison with the results of other radiative transfer models. In particular, a procedure that employs line-by-line technique (already used for the analysis of VIMS solar occultations, [6]) coupled with the DISORT radiative transfer code is extensively used for validation. The main results of these comparisons will be presented.

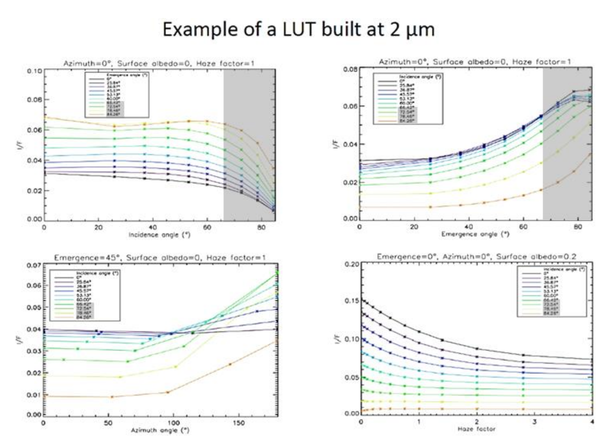

Figure 1: Examples of look-up tables for different values of the observational parameters. The gray area indicates those angles for which the plane-parallel

approximation (used by SHDOMPP) begins not to be adequate anymore.

3. Inversions and First results

An ad-hoc method is developed to use the LUTs in order to invert the VIMS spectra. We are able to get simultaneously information on the surface (albedo) and the atmosphere (aerosol optical depth). We focus mainly on the spectral windows in the near-IR, the 2 μm one in particular. This analysis will also allow us to test our knowledge of the gaseous absorptions on the spectral windows and their surroundings.
The results of the inversion on VIMS datacubes of some regions of interest will be shown. One important example will be the Huygens landing site, extensively observed by several Cassini instruments, which will allow us to compare our output with other simultaneous observations and inversion methods.
Potentially, any region with overlapping datacubes with different observational conditions are interesting to test the method and extract meaningful information; an example is the mosaic of the Aztlan region observed by the two T13/T17 flybys (Fig. 2). We will show some examples.

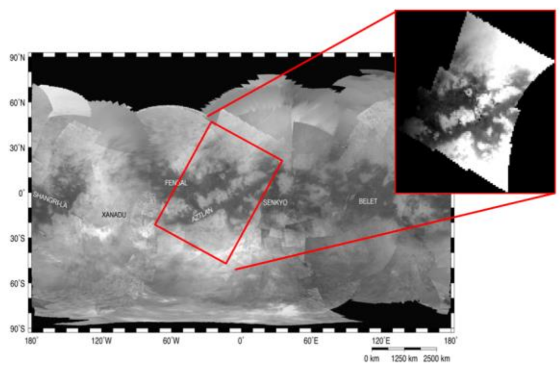

Figure 2: example of mosaic composed by different VIMS datacubes. In this case, observations of the Aztlan region by the T13 and the T17 flybys.

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