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Surface changes in mid-latitude regions on Titan

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Abstract

We present a study focused on the mid-latitude and close to the equator surface regions on Titan that present an interest on their spectral behavior and/or morphology. These are regions where spectroscopic anomalies have been reported in the evolution of the brightness and several interpretations have been proposed (cryovolcanic candidates, evaporates, lacustrine, etc [1;2;5]). Also in our work here we have included analysis of some undifferentiated plains (also referred to as 'blandlands'), which are vast expanses of terrains that appear bland in the radar data [3]. By applying a Radiative transfer code [4;2] we have analyzed these regions to look for evolution with time through their spectral behavior. We use as reference point and calibration tool the surface albedo retrieval of the Huygens Landing site (Titan's ground truth) and we also check the variability of the surface albedo of these regions against areas that are not expected to change with time (e.g. dune fields), by retrieving their albedo differences at all wavelengths [2]. We report here surface albedo changes with time for some of these regions of interest that imply connection to exogenic and/or endogenic processes.

1. Context/Data

In order to unveil Titan's surface nature, determining the surface composition of different units, along with their morphological expressions is of high importance. Matching the surface units with specified mixtures of materials would shed light on the interconnection between the interior, surface, and atmosphere. The Cassini VIMS obtains spectro-imaging data of Titan's surface from flybys performed during the last ten years, in the 0.8-5.2 μm range. The data from the seven narrow methane spectral "windows" centered at 0.93, 1.08, 1.27, 1.59, 2.03, 2.69-2.79 and 5 μm provide some information on the lower atmospheric context and the surface parameters. Atmospheric scattering and absorption need to be clearly evaluated before we can extract the surface properties. Here we focus on areas that are close to the equator and are of geological interest. The first type of geological units are the possible active regions due to exogenic or endogenic processes namely Tui Regio (20°S, 130°W), a 1500-km long flow-like feature, Hotei Regio, that includes volcanic-like features (26°S, 78°W), and Sotra Patera (15°S, 42°W); an area consisting of several units including the lobate flows area Mohini Fluctus and some of the highest mountains on Titan, Doom and Erebor Montes [1]. The second type of geological unit is the undifferentiated plains that appear relatively featureless at radar wavelengths, with no significant topography and their origin remains a mystery [3]. For the first type of regions of interest we are using VIMS data from 2005-2009 and for the blandlands from 2010-2012. In order to validate our results, we use four test case areas, which are expected not to change with time in terms of surface albedo (e.g. dunes) [2] (Fig. 1).

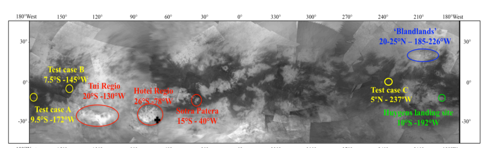

Figure 1: The areas of interest identified on a VIMS mosaic at 2.03 μm. The red ellipses surround Tui Regio, Hotei Regio, and Sotra Patera. The blue ellipse surrounds the portion of the 'blandlands' that we test. The green circle indicates the Huygens landing site (HLS) area. The yellow circles indicate the test case areas 'Test case A', 'Test case B' and 'Test case C' that provide reference to Tui, Sotra and the 'blandlands' respectively and the black cross corresponds to the reference point we use for Hotei Regio [2].

2. Methods

We are using a radiative transfer method, which is a 1-D multi-stream RT code based on the open-source solver SHDOMPP [4]. We have used as inputs most of the Huygens Atmospheric Structure Instrument (HASI) and the Descent Imager/Spectral Radiometer (DISR) measurements, as well as new methane absorption coefficients, which are important to evaluate the atmospheric contribution and to allow us to better constrain the real surface alterations, by comparing the spectra of these regions [4] (Fig. 2).

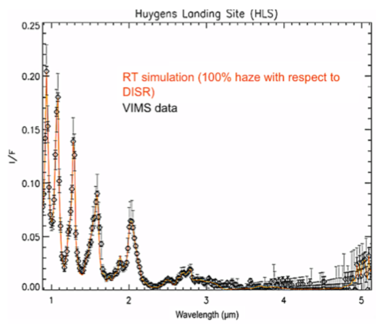

Figure 2: Best fit of the spectrum of the Huygens Landing Site (HLS) showing all the methane windows (VIMS HLS data in black, and RT simulation in orange).

3. Results

The analysis of Hotei Regio data from 2004 to 2009 does not show any significant surface albedo variations, within the uncertainties affecting the unfavorable geometry for radiative transfer analysis with a plane parallel code of these datasets. The undifferentiated plains remain unchanged while Tui Regio and Sotra Patera show surface albedo fluctuations with time. Tui Regio's surface albedo spectrum remains the same with time, only its overall brightness diminished from 2005 to 2009. The Sotra Patera area became brighter within a year from 2005 by a factor of 2, especially at short wavelengths. We have also tested, for approximately the same periods of time, three surface reference points that correspond to dune fields and found that they did not show similar changes in surface albedo. We therefore show that temporal variations of surface albedo (in chemical composition and/or morphology) exist for some areas on Titan's surface, but that they differ from one region to the other [6]. This could be due to diverse, past and/or ongoing formation processes (endogenic and/or exogenic, possibly cryovolcanic).

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References

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