EPSC Abstracts
Vol. 8, EPSC2013-88-1, 2013
European Planetary Science Congress 2013

Surface albedo changes with time on Titan's possible cryovolcanic sites: Cassini/VIMS processing and geophysical implications

A. Solomonidou (1,2), A. Coustenis (1), M. Hirtzig (1,3), E. Bratsolis (4), P. Drossart (1), G. Bampasidis (1,4), K. Kyriakopoulos (2), S. Le Mouélic (5), S. Rodriguez (6), K. Stephan (7), R. Jaumann (7), F. Sohl (7), F.W. Wagner (7), H. Hussmann (7), R.M.C. Lopes (8), C. Sotin (5,8), R. H. Brown (9), K. St. Seymour (10,11) and X. Moussas (4)

(1) LESIA - Observatoire de Paris, CNRS, UPMC Univ Paris 06, Univ. Paris-Diderot – Meudon, 92195 Meudon Cedex, France (asolomonidou@geol.uoa.gr), (2) National and Kapodistrian University of Athens, Department of Geology and Geoenvironment, Athens, Greece, (3) Fondation La Main à la Pâte, Montrouge, France, (4) National and Kapodistrian University of Athens, Department of Physics, Athens, Greece, (5) Université de Nantes, Laboratoire de Planétologie et Géodynamique, Nantes Cedex 03, France, (6) Laboratoire AIM, Université Paris Diderot, Paris 7/CNRS/CEA-Saclay, DSM/IRFU/SAp, Centre de l'Orme des Merisiers, bât. 709, 91191 Gif sur Yvette, France, (7) DLR, Institute of Planetary Research, Rutherfordstrasse 2, D-12489 Berlin, Germany, (8) Jet Propulsion Laboratory, Pasadena, California, USA, (9) Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ 85721, United States, (10) University of Patras, Department of Geology, Patras, Greece, (11) Concordia University, Department of Geography, Montreal, Canada.

Abstract

We present a study on Titan's possibly cryovolcanic and varying regions as suggested from previous studies [e.g. 1;2;7]. These regions, which are potentially subject to change over time in brightness and are located close to the equator, are Tui Regio, Hotei Regio, and Sotra Patera. We apply two methods on Cassini/VIMS data in order to retrieve their surface properties and monitor any temporal variations. First, we apply a statistical method, the Principal Component Analysis (PCA) [3;4] where we manage to isolate regions of distinct and diverse chemical composition called 'Region of interest – RoI'. Then, we focus on retrieving the spectral differences (with respect to the Huygens landing site albedo) among the RoIs by applying a radiative transfer code (RT) [5;3]. Hence, we are able to view the dynamical range and evaluate the differences in surface albedo within the RoIs of the three regions. In addition, using this double procedure, we study the temporal surface variations of the three regions witnessing albedo changes with time for Tui Regio from 2005-2009 (darkening) and Sotra Patera from 2005-2006 (brightening) at all wavelengths [3]. The surface albedo variations and the presence of volcanic-like features within the regions in addition to a recent study [6] that calculates Titan's tidal response are significant indications for the connection of the interior with the cryovolcanic candidate features with implications for the satellite's astrobiological potential.

1. Context/Data

The determination of Titan's surface chemical composition is critical in order to unveil its geology and investigate the interactions between the interior, the surface and the atmosphere. The Cassini VIMS obtained data of Titan's surface from flybys performed during the last nine years. In the 0.8-5.2 μm range, this spectro-imaging data showed that the surface consists of a multivariable geological terrain hosting complex geological processes. The data from the seven narrow methane spectral "windows" centered at 0.93, 1.08, 1.27, 1.59, 2.03, 2.8 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. In this study we focus on the following cryovolcanic candidates [7;9] and potentially varying regions: Tui Regio (20°S, 130°W) [8], a 1500-km long flow-like figure, Hotei Regio (26°S, 78°W) [1], a 700-km wide volcanic-like terrain and Sotra Patera (15°S, 42°W), an area consisting of interesting sub-areas like the lobate flows area Mohini Fluctus and some of the highest mountains on Titan, Doom and Erebor Montes [7].

2. Methods

We are sequentially using two methods in order to acquire the optimal result from the data set. First, PCA, which is a statistical method, decorrelates the features visible on many similar images into a new set of images that show the main features only, sorted by frequency of appearance. We have tested this method on the previously studied Sinlap crater [10], delimitating compositional heterogeneous areas compatible with the published conclusions. Secondly, the radiative transfer method is a 1-D multi-stream RT code based on the open-source solver SHDOMPP. 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 [5]. Figure 1 presents the surface albedo ratios from RT as selected with PCA of the brightest (red) and the darkest (green) RoIs.

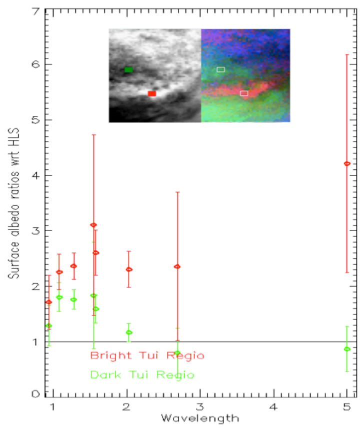

Figure 1: PCA on VIMS data (picture within plot - the red spot marks the bright area, the green the dark area) and retrieval of surface albedo ratios with RT between the bright and the dark Tui Regio RoIs with respect to the Huygens landing site albedo.

Furthermore, we study the temporal surface variations of the three regions at all wavelengths. In order to validate our results we applied the same method for the same periods of time on two dark dunes fields as test cases and did not find any changes in surface albedo (e.g. Fig. 2).

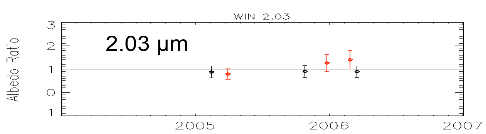

Figure 2. Time variation of Sotra Patera of the average surface albedo obtained within the 2.03 μm methane window. The red marks correspond to Sotra Patera data and the black ones to the test case dunes field centered at 172°W-7.5°S.

3. Results

We have isolated 2 regions (RoIs) in Tui Regio, Hotei Regio and Sotra Patera with PCA that have different spectral response as showed by the radiative transfer simulation (e.g. Fig. 1). The dynamical range in surface albedo within the three areas indicates that the bright RoIs are always brighter than the dark by significant amounts. For Tui Regio and Hotei Regio the largest differences in surface albedo are in the longer wavelengths while for Sotra Patera the offsets are rather homogenously distributed throughout the spectrum with the largest ones at 5μm. We then study the temporal surface variations of the three regions.

Our findings indicate a significant darkening for Tui Regio from 2005-2009 (at all wavelengths). For Sotra Patera a brightening is observed from 2005-2006 (Fig. 2). On the contrary, the dunes fields' test cases did not change with time. Hotei Regio has been previously suggested to present brightness variations over a two-year period (2004-2005) [3]. However, we find that to-date available observations of that region present issues (e.g. geometry) prevent an accurate application of our RT model to infer surface information with the desired accuracy. The surface albedo variations together with the presence of volcanic-like morphological features suggests that the cryovolcanic candidate features are connected to the satellite's deep interior, which could have important implications for the satellite's astrobiological potential. This idea has been recently augmented by the construction of new interior structure models of Titan and corresponding calculations of the spatial pattern of maximum tidal stresses [6].

Acknowledgements

A. S. has been co-financed by the European Union (European Social Fund – ESF) and Greek national funds through the Greek Operational Program "Education and Lifelong Learning" of the National Strategic Reference Framework (NSRF) - Research Funding Program: "Heracleitus II. Investing in knowledge society through the European Social Fund."

References

[1] Soderblom, L.A. et al.: Icarus 204, 610-618, 2009. [2] Nelson, R. et al.: Icarus 199, 429-441, 2009. [3] Solomonidou, A., et al.: In prep., 2012. [4] Stephan, K. et al.: PSS 56, 406–419, 2008. [5] Hirtzig, M. et al.: submitted at Icarus, 2013. [6] Sohl, F. et al.: submitted at JGR, 2013. [7] Lopes, R.M.C., et al.: JGR 118, 1-20, *2013.* [8] Barnes, J.W. et al.: GRL 33, L16204, 2006. [9] Solomonidou et al.: PSS 77, 104-117, 2013. [10] Le Mouélic et al.: JGR 113, E04003, 2008.