OBSERVATION OF ONTARIO LACUS ON TITAN WITH CASSINI/VIMS AT 17 MONTHS INTERVAL. T. Cornet[1], S. Le Mouélic[1], O. Bourgeois[1], S. Rodriguez[2], C. Sotin[1,3], J. W. Barnes[4], R. H. Brown[5], K. H. Baines[3], B. J. Buratti[3], R. N. Clark[6], P. D. Nicholson[7], [1]*Laboratoire de Planétologie et de Géodynamique de Nantes, UMR 6112, CNRS, Université de Nantes, Faculté des Sciences et Techniques, 2 rue de la Houssinière BP92208 44322 Nantes Cedex 3, France.* [2]*Laboratoire AIM, Centre d'étude de Saclay, IRFU/Sap, Centre de l'Orme des Merisiers, bât. 709, 91191 Gif/Yvette Cedex, France.* [3]*Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Drive, Pasadena, CA 91109, USA.* [4]*Department of Physics, University of Idaho, Engineering-Physics Building, Moscow, ID 83844, USA.* [5]*Department of Planetary Sciences, University of Arizona, Tucson, AZ 85721, USA.* [6]*United States Geological Survey, Denver, CO 80225, USA.* [7]*Department of Astronomy, Cornell University, Ithaca, NY 14853, USA. (thomas.cornet@univ-nantes.fr).*

Introduction

In June 2005, the Imaging Science Subsystem (ISS) onboard the Cassini spacecraft detected a large (235 km long) and dark feature, surrounded by a bright and smooth area at the surface of Titan, Saturn's largest moon [1]. This feature has been interpreted as a lake and is named Ontario Lacus. In December 2007, the Visual and Infrared Mapping Spectrometer (VIMS) imaged Ontario Lacus with a resolution of 830 m/pixel [2]. Concentric features resembling shorelines were observed along its margins [2] and the material present in the lake was spectroscopically identified as liquid ethane (in addition to methane, diazote and other light hydrocarbons) [3]. In March 2009, VIMS acquired a new set of images of Ontario Lacus, with a resolution of 2 km/pixel.

VIMS is able to image Titan's surface in seven methane atmospheric windows centered at 1.08, 1.27, 1.59, 2.01, 2.69, 2.79 and 5 μm [4]. However, the interpretation of surface features in these atmospheric windows is often hampered by the strong scattering and absorbing contributions of Titan's thick and hazy atmosphere. The 5 μm window, where the scattering by the haze particles becomes negligible, is by far the weakest affected by these effects [5]. Photometric surface properties might also introduce variations between images acquired with very different viewing geometry [6, 7]. We are currently investigating an empirical method to correct these photometric and atmospheric effects to obtain sharp images of Titan's surface. We applied this method to VIMS observations of Ontario Lacus during T38 and T51 flybys. We then discuss whether surface changes (such as variations in the location, width or spectral properties of the shoreline) occurred during the 17 months time lapse between these flybys.

Photometric and atmospheric corrections in 1.08, 1.27, 1.59 and 2.01 μm methane atmospheric windows

First, we need to evaluate the influence of the atmosphere on the VIMS images, and particularly the scattering effects of aerosols in the 1.08, 1.27, 1.59 and 2.01 μm methane atmospheric windows. We co-added several channels to increase the signal-to-noise ratio [8]. All these windows contain an atmospheric signal (the ray passes through the entire atmosphere before reaching the surface) in addition to the surface reflectance. In the spectral regions of the bottom of the methane atmospheric bands (centered at 0.98, 1.16, 1.39, 1.79 and 2.21 μm), the photons are absorbed by gases (mainly methane) and never reaches Titan's surface.

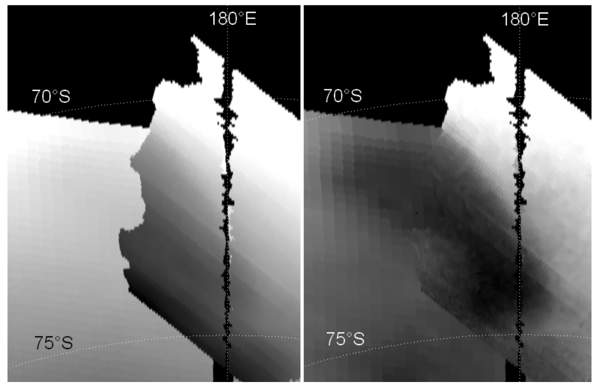

Figure 1: Corrections of the 1.08 μm methane atmospheric window in the VIMS T51 Ontario Lacus observation. Left : raw image ; Right : image after atmospheric and photometric correction.

We consider only single scattering by the atmosphere. We use the Lommel-Seeliger law in equation 1 [9] with an isotropic phase function ($P(g) = 1$) and the methane transmission in the windows is assumed to be equal to 1. The influence of viewing geometry is only dependent of the cosines of incidence ($\mu_0 = \cos i$) and emergence ($\mu = \cos e$). w is the single-scattering albedo of the atmosphere in the methane atmospheric bands and of the surface and the atmosphere in the methane atmospheric windows.

$$r(i, e, g) = \frac{w}{4\pi}\,\frac{\mu_0}{\mu_0 + \mu}\,P(g). \quad (1)$$

We obtain the surface reflectance after dividing the images by $\mu_0/(\mu_0 + \mu)$ and substracting an average image of the atmosphere (the mean of the bottom of methane atmospheric bands) amplified by a factor k (accounting for scattering by upper and lower atmosphere, in the same order as those in [10]). A result of this correction on Ontario Lacus is shown on figure 1 for the 1.08 μm channel, which is the most affected by the blurring effect of the scatterers in the atmosphere. Lake margins are visible on the corrected image, whereas they were barely detectable in the raw image.

Ontario Lacus seen in the 5μm methane atmospheric window

Atmospheric aerosol scattering is negligible at 5 μm. Although our previous atmospheric and photometric

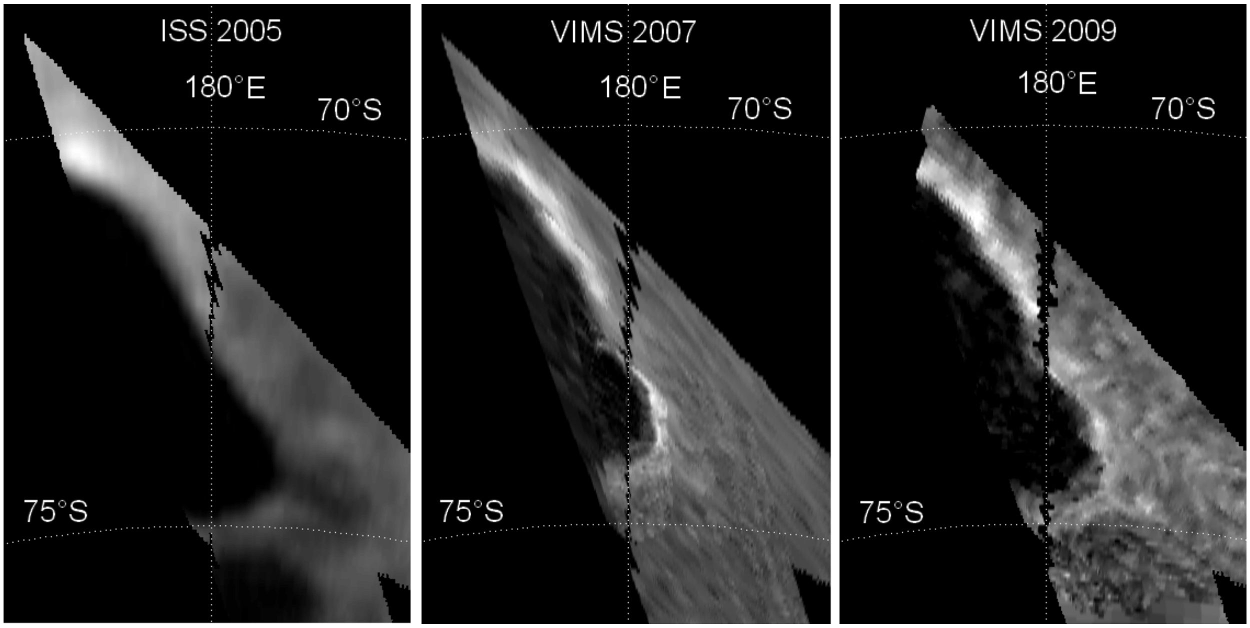

Figure 2: Ontario Lacus seen during three different flybys with about a 2 years interval for each one. Left: Cassini/ISS image (2005) at 0.938 μm ; Middle: Cassini/VIMS T38 flyby (2007) at 5 μm ; Right: Cassini/VIMS T51 flyby (2009) at 5 μm. No major change in the shape is observed between the three images, at least at the considered spatial resolution.

corrections are promising, the 5 μm methane atmospheric window is therefore the most appropriate to determine the characteristics of the surface free of atmospheric effects. We have corrected the T38 and T51 VIMS images of Ontario Lacus in the 5 μm window by a $\mu_0/(\mu_0 + \mu)$ factor.

To compare images of the two flybys, we have resampled the VIMS T38 Ontario Lacus images to the resolution of the T51 images, and we have applied the same contrast to both images. During the T38 flyby, only a part of the lake was imaged. A mask was applied on the T51 images to restrict the analysis to the common area which has been observed. When applying the mask, we noticed a spatial offset of about 18 km between the two VIMS images. This offset can be due either to approximations in the pointing of the instrument during the acquisition or to a tilt in Titan's spin axis, as was already observed by Cassini/Radar during the prime mission [11]. The resulting images are shown in figure 2 with an additional image taken at 0.938 μm by ISS in 2005.

Results

Both VIMS images in figure 2 show clearly two annuli brighter than the lake's interior. The darkest one, which is also visible in the corrected 1.08 μm channel (in figure 1), at the southern margin of the lake, has been previously interpreted as an exposed lakebed, while the other one has been interpreted as sediments deposited in the past when the level of the lake was higher [2]. The lakebed is not visible in the ISS image. We can't ascribe with certainty this difference between VIMS and ISS images to changes in the level of the lake because the spatial resolution of the ISS image differs from that of the VIMS images and because atmospheric scattering effects are particularly strong at 0.938 μm. No striking change appears between the two VIMS images. Any possible changes in the lake contour are therefore necessarily smaller than the resolution of the images (2 km/pixel). This is consistent with the idea that the lake is filled with ethane (which is suspected to cause no significant changes in the shoreline location on observable timescales) rather than methane (which is suspected to cause seasonal or secular changes due to its instability on Titan's surface).

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