CASSINI VIMS AND RADAR ALTIMETER JOINT STUDY OF TITAN SURFACE. S. Rodriguez[1], M. Crapeau[2], S. Le Mouelic[3], Ph. Paillou[2], J.W. Barnes[4], R.H. Brown[5], C. Sotin[3,6], S. Wall[6], and the VIMS and RADAR science teams, [1] Laboratoire AIM, Centre d'étude de Saclay, IRFU/Sap, Centre de l'Orme des Merisiers, bât. 709, 91191 Gif/Yvette Cedex France, (email: sebastien.rodriguez@cea.fr), [2] Observatoire de Bordeaux, France, [3] Laboratoire de Planétologie et de Géodynamique, université de Nantes, CNRS UMR6112, Nantes, France, [4] NASA Ames Research, CA, USA, [5] Lunar and Planetary Lab and Stewart Observatory, University of Arizona, Tucson, USA, [6] Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, USA.

Introduction: The Cassini-Huygens mission reached the saturnian system on July 1st 2004. Titan, one of the primary scientific targets of the mission, is veiled by an ubiquitous thick haze **[1]**. Its surface is unreachable to ultraviolet and visible wavelengths, but can be seen in some infrared atmospheric windows and at centimeter wavelengths, in the case of an unclouded low atmosphere **[2,3]**.

Onboard the Cassini spacecraft, the VIMS (Visual and Infrared Mapping Spectrometer) instrument has already proved to be able to successfully pierce the veil of the hazy moon and image its surface in the infrared wavelengths, taking hyperspectral images in the range 0.3 to 5.1 µm. Since July 2004, VIMS acquired image cubes with spatial resolution ranging from a few tens of kilometers down to 500m per pixel, demonstrating its capability for mapping Titan's surface and studying its composition and geology **[4,5,6,7,8,9,10,11,12]**.

Also in the Cassini orbiter payload is the Ku-band RADAR experiment that can operate at 2.2 cm wavelength in two active modes (SAR and altimeter) **[1,3]**. Exclusively dedicated to Titan's observations, the altimetry mode has been designed primarily to retrieve Titan's surface elevation and study its topography **[1,3]**.

We present here the comparative analysis of the altimeter track recorded during the first Titan flyby (26 October 2004, tagged TA) and VIMS images over the same region acquired during the 13th flyby (30 April 2006). In particular, we present here the first non-topographic analysis of Cassini altimeter data along with a tentative correlation with VIMS observations.

TA Cassini altimeter track: During the TA Titan flyby (26 October 2004), Cassini RADAR recorded its first altimeter track, beginning just after the end of the the SAR swath acquisition **[1,3]** (see **figure 1**). The linear part of TA altimeter track runs from -10°E to -2°E in longitudes and from 28° to 23.5° in latitudes (yellow circles in **figure 1**). Looking at the leading edge position of the returned altimeter pulse echo gives direct estimation of the relative elevation of Titan's surface (**figure 2a**), with a spatial resolution directly related to the altimeter horizontal resolution (~25 km) and a theoretical vertical precision less than 100 meters. Calculations show very smooth reliefs along the track with a maximum of 200 meters elevation differences over 400 km (**figure 2a**).

Along with elevation restitution, Cassini altimetry data can also be used to retrieve the radar reflectivity of Titan's surface, as it is done on Earth in icy con-

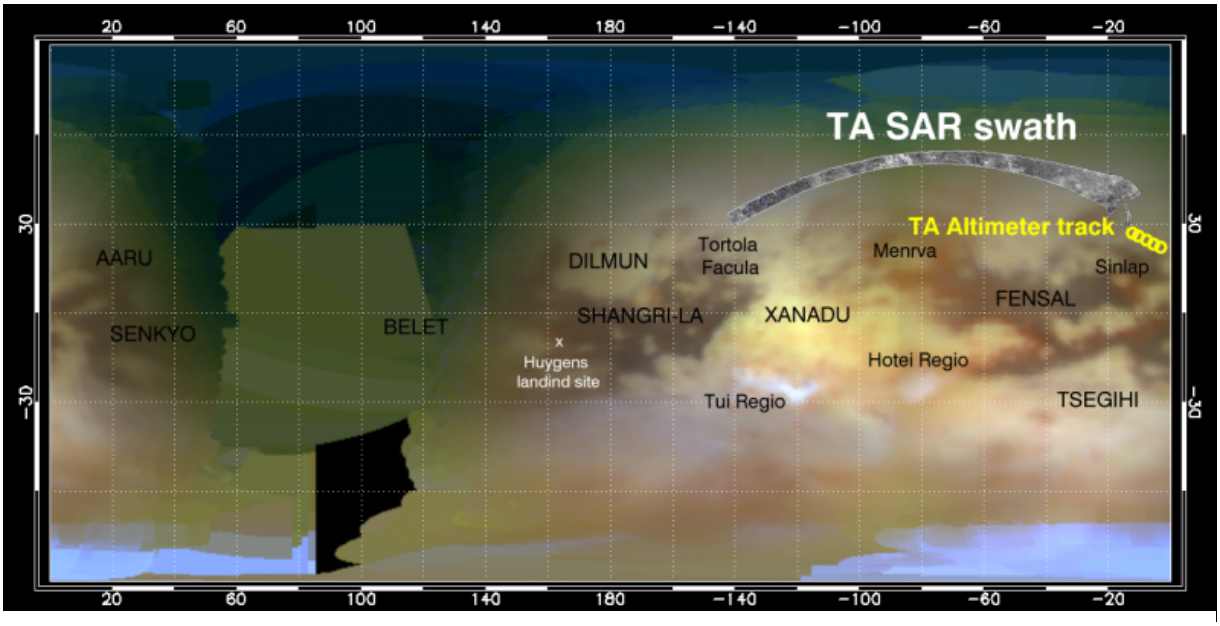

Figure 1. TA SAR swath and altimeter track (yellow circles) overlying a global view of Titan's surface imaged by VIMS **[11]**.

texts like in the Antarctic. The radar reflectivity σ_0 corresponds to the total energy echoed that depends essentially on Titan's surface roughness and composition. The computed σ_0 presents a clear parabolic signal decrease over 100 km, strongly correlated with the smooth surface depression inferred from topography estimation, witnessing a change in surface nature at this location (between 27° and 25.5° in latitudes - see **figures 2a and 2b**). It might be due to the local presence of a more microwaves absorbing material located within a large basin.

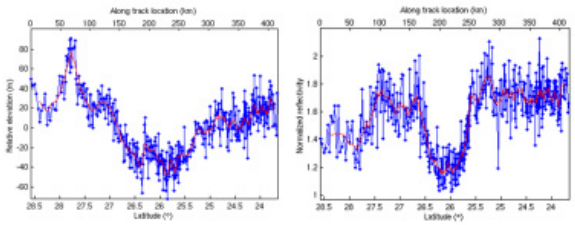

Figure 2. *Left (a):* Surface elevation calculations from TA altimeter data. *Right (b):* Radar reflectivity derived from TA altimeter data.

Comparison with VIMS infrared images: The 30th April 2006 (T13 Titan flyby), the VIMS instrument acquired hyperspectral images over the TA altimeter track. A RGB composite of the best resolved VIMS images of this area, with a mean resolution of 11 km/pixel, is shown in **figure 3 (top)**. This composite image, corrected from atmospheric aerosols contribution, following the method developed by **[9]**, enhances the presence of local enrichments in water ice with bluish tones and dunes fields in brown. On this figure, we can see that the altimeter ground-track, symbolized by a red line, crosses two dark bluish structures, from west to east a 5km-wide lineament and a larger oblong feature respectively, visible in the underlying VIMS data.

We extract VIMS band ratios transects exactly over the TA altimeter track. The cross comparison between VIMS transects and RADAR altimeter reflectivity is presented in **figure 3 (middle and bottom, respectively)**. The radar reflectivity shows particularly strong correlations with the 1.59/1.08, 1.59/1.27 and 2.03/1.27 µm band ratios along the track after 27.5° in latitudes (decreases centered at 26.9° and 26° latitudes), but not with the 1.27/1.08 µm ratio, which is consistent with a local water ice enrichment. These enrichments are geographically linked with the VIMS two dark blue structures, the second being related to the negative topography seen in altimetry data and the greatest decrease seen in radar reflectivity. This may witness an ancient channel, possibly connected to a large basin, where Titan's icy bedrock is more exposed than in the surroundings.

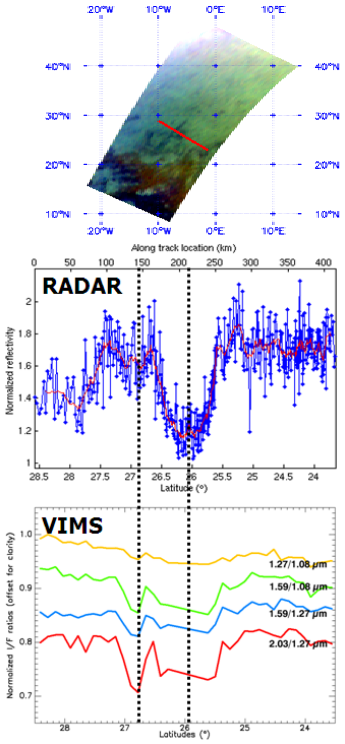

Figure 3. *Top:* RGB color composite of VIMS imaging of Titan's terrains observed over TA altimeter track during T13 flyby, with 1.59/1.27 µm bands ratio as red, 2.03/1.27 µm as green and 1.27/1.08 µm as blue as used in [11]. All VIMS bands are corrected from atmospheric aerosols contribution, following the method developed by **[9]**. The TA Altimeter track is symbolized by the red line. Two dark structures visible in VIMS data crosse the track. *Middle and bottom:* Cross comparison between TA altimeter reflectivity (*middle*) and VIMS band ratio transects over the altimeter track (*bottom*).

References: **[1]** Brown R.H. et al. (2003), *Icarus, 164, 461.* **[2]** Smith P. H. et al. (1996) *Icarus, 119, 336.* **[3]** Rodriguez S. et al. (2003), *Icarus, 164, 213.* **[4]** Sotin C. et al. (2005), *Nature, 435, Issue 7043, 786.* **[5]** Jaumann R. et al. (2006), *P&SS, 54, Issue 12, 1146.* **[6]** Buratti B.J. et al. (2006), *P&SS, 54, Issue 15, 1498.* **[7]** Mc Cord T.B. et al. (2006), *P&SS, 54, Issue 15, 1524.* **[8]** Nelson R.M. et al. (2006), *P&SS, 54, Issue 15, 1540.* **[9]** Rodriguez S. et al. (2006), *P&SS, 54, Issue 15, 1510.* **[10]** Barnes J.W. et al. (2006), *GeoRL, 33, Issue 16, CiteID L16204.* **[11]** Barnes J.W. et al. (2007), *Icarus, 186, Issue 1, 242.* **[12]** Le Mouélic S. et al. (2008), JGR, 113, E04003.