ESTIMATES OF TITAN'S SURFACE PHOTOMETRY IN THE 5 MICRONS ATMOSPHERIC WINDOW USING THE CASSINI *VISUAL AND INFRARED MAPPING SPECTROMETER* (VIMS).

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Introduction: Saturn's moon Titan possesses a thick and opaque atmosphere that veils the surface at almost all wavelengths in the visible and infrared domains. The surface is detected in only a few narrow atmospheric windows centered at 1.08, 1.27, 1.59, 2.01, 2.7 - 2.8 and 5 µm resolved by the Cassini *Visual and Infrared Mapping Spectrometer* (VIMS) instrument [1]. All windows located at wavelengths shorter than 3 µm are strongly affected by the atmospheric scattering due to the aerosols present in Titan's atmosphere -which blurs and masks the details of the surface- whereas the 5 µm window can be considered as free of any atmospheric scattering effects [2]. In the present work, we take advantage of this absence of atmospheric scattering effects to provide estimates of the surface photometry in the 5 µm atmospheric window using Cassini VIMS data.

Previous work: We have produced a global mosaic of Titan by merging the all VIMS cubes acquired between 2004 and 2010, using a series of filters (viewing angles, exposure time, spatial resolution,…), designed to improve the vision of the surface [3]. Several artifacts can be seen in the photometrically uncorrected global mosaic of Titan taken at 5 µm (Figure 1 top). These appear as seams, which are caused by the varying viewing angles (incidence, emission, phase) between the data acquired during the different flybys, in addition to possible changes due to the cloud cover with time.

A heuristic method has been proposed in [3] to correct: (1) for the atmospheric scattering effects present at the short-wavelengths atmospheric windows, and (2) for the surface photometry based on the correlations between the 5 µm signal recorded by VIMS and several photometric factors. This method is based on the following simplified equation:

$$(I/F)_{VIMS} = (I/F)_{surf}\ f(i,e,g)\ e^{-\tau \times airmass} + (I/F)_{scattered}, \quad (1)$$

where $(I/F)_{VIMS}$ is the signal recorded by the VIMS instrument, $(I/F)_{surf}$ is the signal coming from the surface only, $f(i,e,g)$ is the photometric function of the surface (depending on the incidence i, emission e and phase g angles), $e^{-\tau \times airmass}$ represents the absorption by atmospheric gases and aerosols, and $(I/F)_{scattered}$ is the pure atmospheric scattering additive component, which decreases with increasing wavelength.

Using this simplified equation to describe the signal recorded by VIMS in a wide area of apparently homogeneous albedo, we initially found that the surface photometry estimated at 5 µm can be modeled by the Lambert law at first order, with a strong dependence with the cosine of the incidence angle [3]. The global mosaic taken in the 5µm window and corrected by the cosine of incidence is represented in Figure 1 (middle).

New results: further improvements of the surface photometric function: Our objective here is to refine the surface photometric function based on the same mosaic and similar correlation techniques, using a wider set of photometric factors and a bigger test area including southern regions. We still assume that the $(I/F)_{scattered}$ term of Eq. 1 is negligible at 5 µm. The studied areas are located in the northern and southern mid-latitudes, where the surface seems to be quite homogeneous at VIMS spatial resolution, so that the intrinsic albedo variations can be considered as nearly constant at first order compared to variations due to the viewing angles.

The new photometric function must (1) maximize the correlation factor R^2 between the signal at 5 µm and the tested photometric functions and (2) minimize the standard deviation of the $(I/F)_{surf}$ once the mosaic has been corrected. We tested various empirical laws such as the Lambert law, the Lommel-Seeliger law, or the Lunar-Lambert law [4] with different phase functions (isotropic, Henyey-Greenstein, Rayleigh, …). We found that the strongest correlation between the $(I/F)_{VIMS}$ and the photometric function and the lowest standard deviation of $(I/F)_{surf}$ are found using a Lunar-Lambert law with a Rayleigh phase function (R^2 close to 0.9).

The global mosaic in the 5 µm window corrected by the new surface photometric function is represented in Figure 1 (bottom). An improvement is obtained both in equatorial regions and near the north pole. Further investigations of the 5 µm window will bring additional constraints on the photometric behavior of the surface and on possible absorption effects due to the atmosphere.

References: [1] Sotin C. et al. (2005), *Nature*, 435, 786-789. [2] Rodriguez S. et al. (2006), *PSS*, 54, 1510-1523. [3] Le Mouélic S. et al. (2012), *PSS*, 73, 178–190. [4] Buratti B. and Veverka J. (1983), *Icarus*, 55, 93-110.

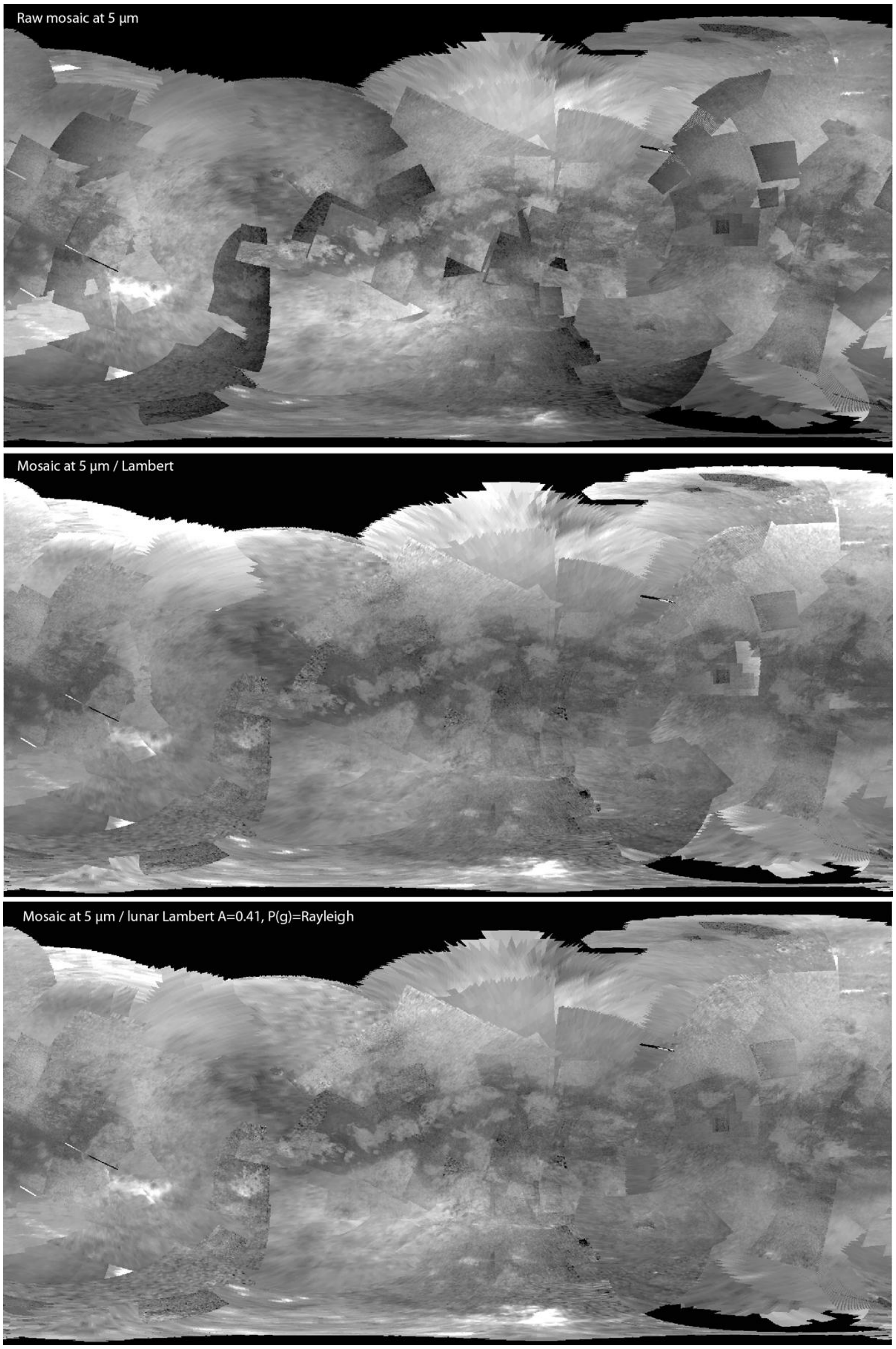

Figure 1: VIMS global mosaic of Titan's surface at 5 µm from data acquired between 2004 and 2010. Top: raw mosaic ; middle: mosaic corrected using the Lambert cosine law ; bottom: mosaic corrected using the proposed Lunar-Lambert law [4] with a Rayleigh phase function.