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10 years of Cassini/VIMS observations at Titan

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Abstract

During the first Titan flyby in October 2004, the Visual and Infrared Mapping Spectrometer (VIMS) demonstrated that it can map Titan's surface in seven atmospheric windows between 0.9- and 5.1-µm. Since then, the instrument has provided several high-resolution images of Titan's surface, including the Huygens landing site and a large number of images at 5-km sampling. At 5-µm, scattering is limited as demonstrated by the observation of specular reflections on the North-Pole lakes and seas. The VIMS has recorded the evolution of the cloud coverage and its dramatic evolution around the equinox. Solar occultation observations have also provided information on the atmospheric composition and the characteristics of the aerosols. After reviewing the main findings, this paper describes the upcoming observations until the end of mission in September 2017.

1. Introduction

Before the Cassini mission, Titan's surface was 'terra incognita' because its dense atmosphere precluded high-resolution observations by the cameras onboard the Voyager spacecraft. However, a few years before the Cassini orbit insertion around Saturn, observations from Earth-based telescopes and space telescopes had demonstrated that Titan's surface can be observed in seven atmospheric windows (Table 1) in the infrared at wavelengths where the methane absorption is weak and the optical depth of the atmospheric haze is sufficiently low [1]. However, the poor resolution from Earth, or Earth's orbit, only revealed a bright feature on the leading site known as Xanadu. With its 0.5 mrad FoV, the VIMS instrument, which has two mirrors to build images up to 64x64 pixels, has demonstrated that it can observe Titan's surface with a resolution as good as 1 km/pixel when observations are made at a distance of 1,000 km, which is the typical altitude of the Cassini spacecraft at closest approach [2]. Since 2004, the VIMS has provided a wealth of color images that are very complementary to the radar images (section 2). In addition, some spectral channels are characteristic of cloud features and have allowed us to monitor the cloud coverage (section 3) and its evolution during the winter and the spring. Finally, observations of solar occultation provide information on the composition of the atmosphere and the propertie of the haze particles.

2. Observations of the surface

2.1 The Huygens landing site

The Huygens landing site has been mapped by VIMS in order to use the information collected by the Huygens probe during its descent into Titan's atmosphere in January 2005 as a ground truth (Fig. 1).

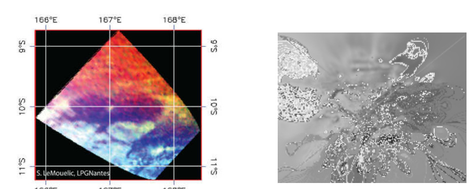

Figure 1: Huygens Landing site: Comparison between the VIMS image and the DISR mosaic from images acquired during the descent.

The very good correlation between the VIMS image and the DISR mosaic allows for a very good precision of the location of the Huygens landing site which is located in a valley surrounded by elevated bright terrains. From higher altitude, one can observe that Huygens landed at the eastern tip of an elevated bright plateau known as Adiri.

2.2 Morphological features

The VIMS has acquired observations of lakes and rivers [3], impact craters [4], plateaus, and dune fields.

2.3 Surface composition

Titan's surface seems to be covered by organic material that hides the ice crust. The 2.7-μm broad window provides key information on its present since the albedo of water ice drops dramatically in this wavelength range. Although the atmospheric contribution in this window is not yet fully understood, which prevents us from definitive conclusions about the presence of water ice, the typical spectra suggest that water ice alone is not present at the VIMS resolution.

The 5-μm broad window includes several features characteristic of organics [5].

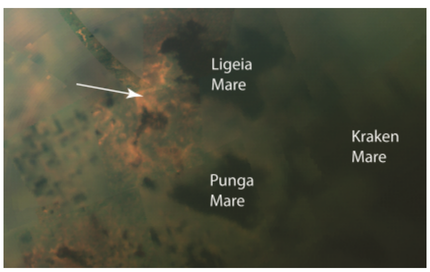

Figure 2: The three large seas of Titan. The arrow points toward a 5-μm bright feature interpreted as evaporites [6].

2.4 Seas and lakes

Titan is the only body in the solar system, besides Earth, to have stable liquid bodies at its surface. VIMS not only maps these seas and lakes [3] but also observes specular reflections [7] that confirm the liquid state of the lakes. Bright terrains adjacent to the lakes suggest the presence of evaporite material (Fig. 2). Absorption features in the 2-μm atmospheric window suggest the presence of ethane in the lakes [8].

2. Atmospheric observations

3.1 Cloud coverage and evolution

In 2004, the North Pole was not illuminated. In addition, it was covered by a polar hood. As equinox approached, the North polar cloud vanished. Quickly after equinox, a South Polar Cloud formed. The VIMS monitors the evolution of the cloud system [9].

3.2 Properties of the haze

Solar occultations have provided information on the physical characteristics of the haze that is falling into Titan's atmosphere and eventually covers its surface [10]. Observations were obtained at different latitudes to compare wiht the change in density predicted by Global Circulation Models (GCMs).

4. Conclusions

Future observations of Titan's surface by the VIMS will focus on the northern pole in order to monitor the evolution of the three major seas and the lakes during the spring, whether they recede or expend. In addition, several specular reflection observations are implemented to look for waves, which would provide constrain on GCMs.

Acknowledgements

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