EPSC Abstracts
Vol. 5, EPSC2010-893, 2010
European Planetary Science Congress 2010

High resolution mapping of Titan's surface in the infrared: implications for future missions

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Abstract

The Visual and Infrared Mapping Spectrometer (VIMS) discovered that a large percentage of the light at 5 microns goes directly through Titan's atmosphere without much scattering. This property is used to develop an infrared camera which can obtain images of Titan's surface with a resolution of 50 meters per pixel at altitudes less than 2300 km. Such a camera could be used by future missions to Titan.

1. Introduction

The Cassini/Huygens mission has discovered the large diversity of geological landscapes on Titan [e.g. 1] including dune fields, lakes, plateaus carved by rivers, mountains, impact craters, and flow features. A better understanding of the geological history requires high-resolution mapping of the surface as this has been demonstrated for other solar system objects.

Before the Cassini mission, it was not anticipated that Titan's surface could be observed at optical wavelengths. It was believed that the dense, methane-rich atmosphere would prevent any direct light from reaching the surface. VIMS data show that Titan's atmosphere is largely transparent at 5 microns.

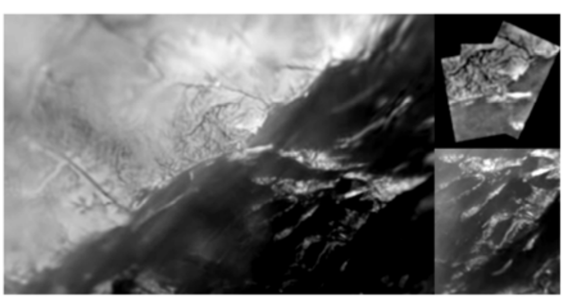

Figure 1: Image of the Huygens site area degraded to 50 m resolution

2. Comparing observations of Titan's surface by Cassini and by Huygens.

When Huygens descended into Titan's atmosphere, its cameras took images of a small spot of Titan's surface with resolution as high as a few meters per pixel [2]. The images taken with a resolution better than 100 meters per pixel allow us to see the rivers and channels which erode a bright highland (Fig. 1). Such images are very useful to quantify the hydrological processes operating on Titan. Unfortunately, the area observed at this resolution is only about 25 km^2.

This area has also been observed by the Synthetic Aperture Radar (SAR) and the VIMS. The SAR has a resolution of 350 m at closest approach. The VIMS image has a resolution on the order of 1 km/pixel. At these resolutions, the rivers are not visible (Fig. 2). In addition, it seems that the optical images observe more contrast than the SAR images. The color-coded image of the Huygens landing site (Fig. 2) was obtained with infrared channels using ratios to remove most of the atmospheric effects (Red = 1.59 µm /1.27 µm ; Green = 2.03 µm /1.27 µm and Blue = 1.27 µm /1.08 µm).

Although the optical images look great at this resolution because they were obtained at altitudes below Titan's haze layer, atmospheric scattering limits the resolution that can be achieved in the near infrared with images taken from outside the atmosphere. VIMS data show that light at 5 microns is transmitted through the atmosphere with limited scattering. Such a property can be used to map Titan's surface.

3. Characteristics of Titan's surface and atmosphere at 5 microns

The VIMS data provide values of I/F where I is the observed radiance and πF is the incoming solar irradiance [3] at the altitude of the spacecraft from 800 km to 5200 km. It has demonstrated that Titan's surface can be observed at 5 microns [e.g. 4] with values of I/F varying from 0 to 5%. Several regions of Titan are characterized by a high I/F ratio at this wavelength including Tui and Hotei regions.

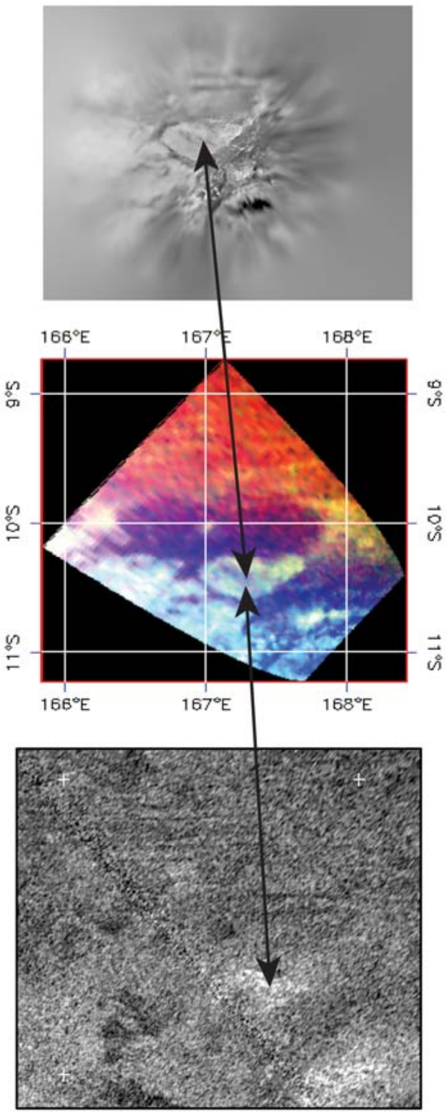

Figure 2: The Huygens landing site area seen by Huygens/DISR (top), Cassini/VIMS (middle), and Cassini SAR (bottom).

In addition, the observation of specular reflection at 5 microns on Kraken Mare [4] suggests that there is little scattering at this wavelength compared to what is happening at shorter wavelengths.

4. Conclusions

That 5-micron light can be used to map Titan's surface has lead us to develop an infrared camera which can observe Titan's surface at resolutions 50 m/pixel or better. Such a camera could take one hundred images at each Titan flyby, which would cover a surface area of 1 M km^2. Such a surface area is about 1.25% Titan's surface. It is about 50 thousand times larger than the area imaged by the Huygens probe.

Such a camera would provide key information on the relationships between the different geological units. It would also help understand Titan's geological history. Finally, it would also provide the information needed for future in-situ mission.

References

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Acknowledgments: This work has been performed at the Jet Propulsion Laboratory, California Institute of Technology under contract with NASA.