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Spectral properties of fluvial terrain on Titan: An update

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Abstract

Spectral properties of fluvial terrains on Titan are highly relevant in order to characterize fluvial processes as well as to reveal stratigraphic relations between different geologic and/or spectral units. Fluvial landforms at the surface of Titan are often found on bright spectral units, which are interpreted to be elevated terrain with a comparably high albedo in all the atmospheric windows of the near-infrared spectrum. On the other hand, fluvial processes are suspected to account for the deposition of sediments with a certain spectral fingerprint that is similar to the blue surface unit. Interestingly, the spectral footprint of fluvial terrains is often a mixed signature between the bright and the bluish spectral unit.

1. Introduction

Fluvial erosion and valleys on Saturn's moon Titan mark the outcome of a volatile cycle, that is based on methane. The presence of volatile cycles is unique in our Solar System since the range of boundary conditions for such a cycle of matter is very tight. Specifying the distribution of fluvial valleys in relation to the arrangement of spectral surface units is a major concern in order to reveal details on Titan's methane cycle. VIMS-data enable the determination of compositional information about the upper cm or mm of the observed surface. Based on these data, Titan's surface can be categorized into several spectral units, namely the bright, bluish and brown surface units [4, 2, 5].

Many authors propose that the blue spectral units corresponds to fluvial deposits or sediments, since riverbeds of broad channels resolved by VIMS have similar spectral characteristics as the blue surface unit [1, 3]. This statement would implies a very substantial relevance of fluvial erosion on Titan since nearly 7% of its lower latitudes (between 30°N and 30°S) is covered by the blue material.

2. Database

Cassini Radar-SAR swaths, with a spatial resolution of up to 350m/pix, provided the basis to create a global database of potential fluvial features. Channels can be identified by their linear and sinuous shape, through a substantial contrast to their background and sometimes through morphological and geometric recognition features. A number of valleys is arranged in complex dendritic networks, what in turn ascertains their origin from rainfall.

Spectral data from the Cassini-VIMS camera offer the opportunity to investigate the fluvial terrain in terms of their spectral properties. Titan's dense absorbing atmosphere prevents to take advantage of the full capabilities of VIMS' 352 spectral channels. Nevertheless, several atmospheric windows with adequate transmittance remain, that allow sensing of the surface. To enhance the spectral contrast, VIMS images are displayed as RGB-composits, in which each color space represents the quotient between two spectral bands.

Cassini data from the end of the prime mission (until June 2008) and from the beginning of the extended mission (July 2008 to July 2010) provide additional insights into the distribution of geologic features as more and more coverage gaps are closed. Coincidentally, the overlap area between images of the two sensors increased in recent years. Data from the two different image sensors were combined and analyzed in the environment of a Geographic Information System.

3. Observations

Fluvial valleys particularly come up on the bright spectral unit; here they are concentrated on and around Titan's largest bright continent, Xanadu, that is located at the leading hemisphere of the moon (see figure 1 and 2). Current SAR-data (T41 to T48) cover the central and southern part of Xanadu. As on the western edge of that continent, several valleys emerge. Exemplary, the valleys of western Xanadu are depicted in figure 1. Figure 2 shows the recent VIMS coverage of that area.

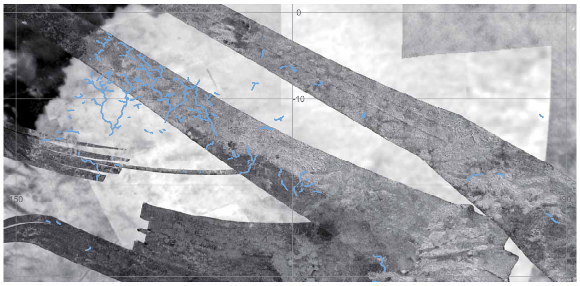

Figure 1: Western Xanadu as imaged by Radar-SAR and ISS (background). Fluvial valleys are highlighted in light blue.

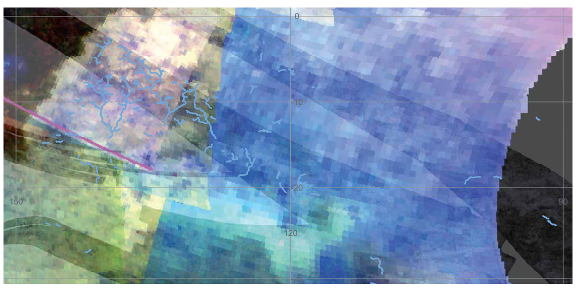

Figure 2: Western Xanadu as imaged by VIMS (RGB-Ratio-composit with R: 1.59/1.27 µm G: 2.03/1.27 µm B: 1.27/1.08 µm superimposed on Radar-SAR). Fluvial valleys are highlighted in light blue.

Extended fluvial terrains are located on the bright continent in the displayed VIMS-composit. However, VIMS also discloses that the bright units exhibits strong variations of the albedo and that the bright terrain is not as homogeneous as the brown and blue units. Spectral investigation of the VIMS-pixel, that relate to the fluvial channels identified by SAR, reveal intermediate spectral properties between the spectral footprint of the bright and the blue surface unit (see figure 3). This effect is certainly due to the small width of the channels relating to the spatial capabilities of the VIMS sensor in this particular region. As a matter of fact, the fluvial pixels analysed here contain not only the area of the relatively narrow river bed but also the surrounding (bright) terrain.

Thanks to the SAR-swath T49 (captured on Dec 21, 2008) a system of channels near 30°S is resolved, that is also covered by VIMS data. Supporting the findings on spectral properties of fluvial landforms, this network is also located on VIMS-bright terrain (not shown here).

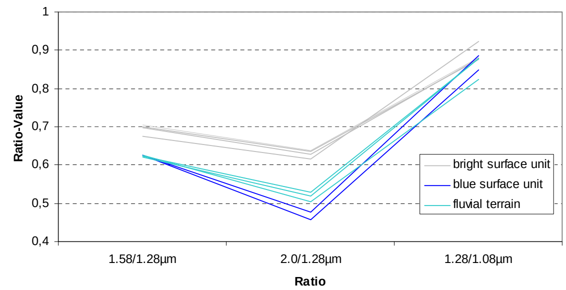

Figure 3: Ratio-spectra of the bright, blue, and fluvial surfaces. Extracted from western Xanadu, VIMS-observations T012.

4. Summary and Conclusions

Generally, fluvial erosion features at Titan's surface appear to be closely associated with the bright spectral unit. This finding is based on a spatial intersection of recent Cassini image data. However, fluvial terrain is characterized by spectral properties intermediate between bright and blue surface units. Considering the effect of mixed pixels, the assumption of a correlation between the blue spectral unit and fluvial sediments can be supported.

The high albedo variance of the bright material observed in figure 2 indicate the proceeding of geologic processes, such as resurfacing by flowing liquids, while the relative homogeneity of the blue and brown surfaces support their possible sedimentary origin.

Acknowledgements

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