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Fluvial features on Titan – Cassini VIMS and Cassini RADAR observations

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Abstract
Fluvial erosion on Titans surface is a topic of special interest in recent years. Erosion caused by a liquid medium could be detected in data captured by the Cassini spacecraft, e.g. in VIMS-images [1], RADAR swaths [2,3] and ISS-data [4]. Numerous fluvial channels have been evidenced in images of Titan's equatorial and polar regions. At some places fluvial incision could be retraced several hundreds of kilometers.
Investigations of VIMS-data suggest that Titan's channels often develop on "bright" regions, i.e. terrain appearing bright at 2µm. These bright regions are expected to be elevated terrain compared to the surrounding dark terrain [5]. This study investigates potential fluvial areas and compares them regarding their appearance in VIMS- and Radar-images. The relation between VIMS-bright and Radar-bright terrain is discussed in the context of the channel-development.

Background
Fluvial channels on Titan appear in Radar-data either bright on dark substrate (at low and mid-latitudes) or dark on a bright background (at high latitudes) [3]. Radar-data with a ground resolution of up to 300m per pixel enable the detection of relatively small-sized channels with lengths of several hundreds of kilometers and width of some hundreds of meters, e.g. [6]. Additionally, morphological properties of the channels, e.g. their dendritic nature, meandering and branching are often apparent in Radar-data.
Cassini-VIMS-data enable a comprehensive spectral analysis through their excellent spectral resolution in 352 spectral bands between 0.3 and 5.1µm. Because of Titan's dense atmosphere optical imaging is limited to a few spectral windows that are widely unaffected by atmospheric influences. Large-sized fluvial channels and networks could also be discerned in VIMS-data. Until now fluvial channels came up on NIR-bright terrain. 2µm-bright terrain is supposed to be composed differently compared to the surrounding. Presumably, the surface of Titan is covered by dark atmospheric deposits. In the case of the bright terrain, this dark mantle is expected to be removed by fluvial erosion. Varying water-ice content could be another source of the dichotomy between dark and bright terrain, e.g. [2].
Channels as well as their outflow areas appear dark in VIMS-images (or blue in color composites) since they transport and deposit the dark atmospheric substance out to the lowlands [2]. Channels could be indirectly recognized through the sometimes frayed boundaries of bright areas. Therefore VIMS-data enable the investigation of channels via their spectral characteristics. The entire channel network as well as the branching and meandering nature of the channels often couldn't be reconstructed through the coarse VIMS resolution of several kilometers. In some cases channels could be identified both by Radar- and VIMS-data, e.g. [2].
Titan's surface consists of 2µm-bright terrain in large parts. Channels are prominent in just 1% of Titans surface [3]. Therefore the presence of bright terrain couldn't be the only constraint for the development of channels. To analyse this relation some examples of equatorial and mid-latitude (potential) channels are investigated where VIMS-data and Radar-swaths overlap.

Observation
To check whether the VIMS-bright substrate accounts for the development of channels two different study sites have been analysed. One of the most prominent examples for correlations between VIMS- and Radar-data could be found at 10°S 100°W within Xanadu (Fig. 1a and 1b) [3]. The selected area is obviously affected by fluvial erosion and appears bright at 2µm as well as at Radar-wavelengths. VIMS-data (Fig. 1a), at a spatial resolution of up to 14km/pixel, point to the presence of surface runoff through brightness variations of adjacent subregions and pixels. The frayed western boundary of the continent affirms the concept of fluvial incision.
Another example (Fig. 2a and b) is located at about 15°N 50°W. This example represents a bright, probably coastal area. Based on investigations of the VIMS-data (Fig. 2a) this area seems to be eroded and washed-out by a liquid medium through the presence of several dark interconnected linear streaks.

Unfortunately, the VIMS-resolution is not sufficient (6km/pixel) to discern the potential channels in detail. The same region as shown in Radar (Fig. 2b) comes up as dark terrain with bright discontinuities that could be interpreted as mountain chains. The Radar-data don't reveal clear channels at this point but features that could be at best interpreted as initial channels. This example reflects the sometimes poor correlation between VIMS- and Radar-data.

Conclusions

Data of the Cassini spacecraft offer an excellent opportunity for studying fluvial erosion on Titan. At some places it's difficult to identify these areas solely by VIMS-data. The presence of VIMS-bright material in proximity to frayed and irregular coastlines seems not to be an evidence for fluvial incision. This study provides one example where VIMS-data indicate the presence of fluvial erosion that could be affirmed by Radar-data. Another example points to an incoherency between VIMS- and Radar-data regarding potential areas of fluvial erosion. A possible explanation for that fact would be that channels at these particular places are too narrow to be resolved with recent sensors. For the examples given here, this explanation is unlikely because VIMS spatial resolution is coarser than Radar-resolution.

Discrepancies between Radar- and VIMS-images still resist since Radar-bright and VIMS-bright areas don't necessarily coincide. These discrepancies could occur because Radar reflectance corresponds to morphological properties of the surface, e.g. its roughness, while VIMS reflectance relates to spectroscopic and therefore compositional properties of the upper surface-layer.

Nevertheless, VIMS provide amounts of additional information once channel regions have confidently been identified. Identifying channels and analysing their morphological properties is possible through Cassini-Radar-data.

References

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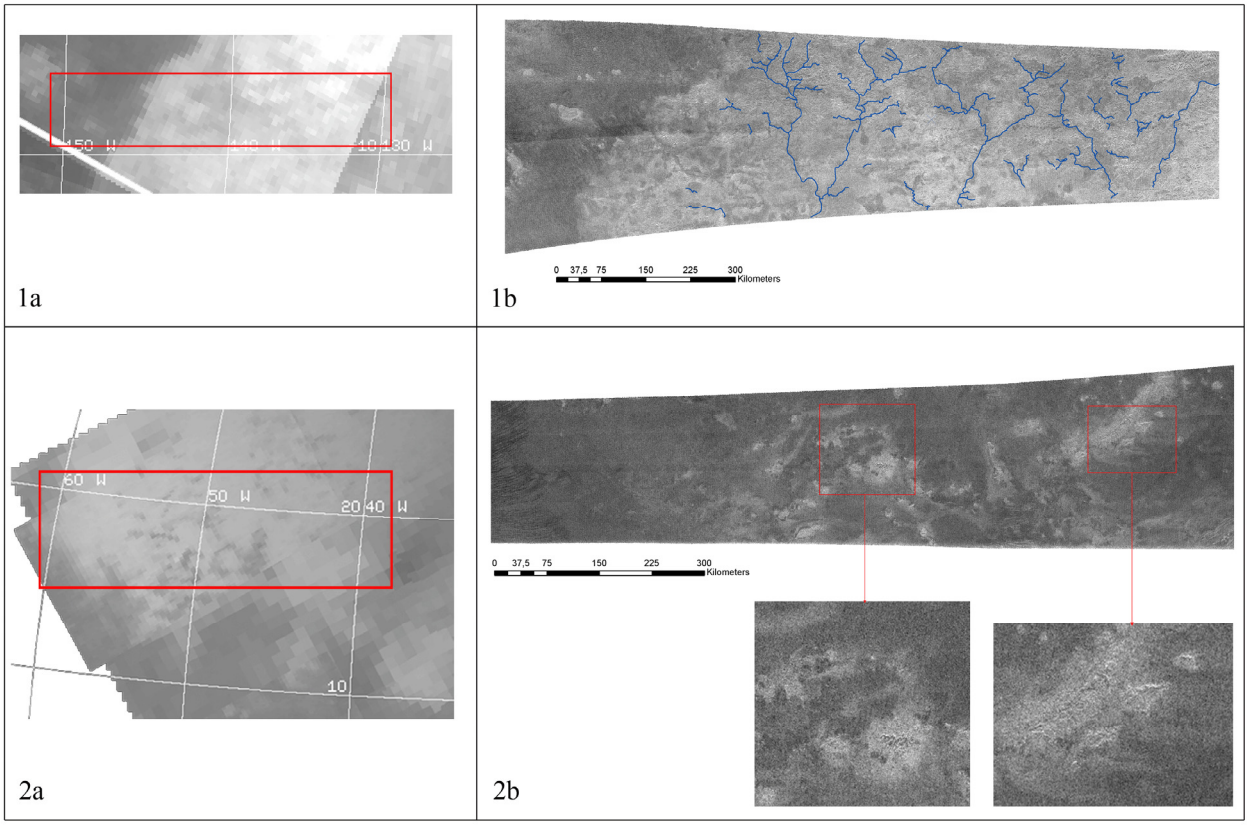

Fig. 1 Fluvial areas on Titan as observed by VIMS (left) and Radar (right). 1: Xanadu-Regio (VIMS: Orbits T20 and T22, Radar: T13). 2: bright unnamed feature conterminous to Fensal (VIMS: Orbit T6, Radar: T3).