VALLEY FORMATION FROM METHANE CONVECTIVE STORMS ON TITAN. M. Langhans[1], R. Jaumann[1,2], K. Stephan[1], R. H. Brown[3], B. J. Buratti[4], R. Clark[5], K. H. Baines[4], P. D. Nicholson[6], R. D. Lorenz[7] and C. Sotin[4].
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Introduction: Fluvial valleys at Titan's surface provide an indication for the action of a volatile cycle based on liquid methane. The surface of the moon is carved by numerous fluvial valleys and valley networks, distributed over all latitudes of Titan.

From atmospheric modelling it is known that intense thunderstorm events could account for fluvial erosion [1,2]. Further, discharge estimates approved the idea of convective storms as they explain the transport of large amounts of sediments [3]. Storm events with long recurrence intervals allow high amounts of liquids to reach the surface, followed by surface runoff and incision of fluvial valleys. Between the thunderstorm events, long periods of dry climatic conditions lasting several tens or hundreds of years are expected.

The episodic character of precipitation and runoff results in certain differences of the channel morphology compared to perennial valleys with a nearly constant discharge. These morphologic characteristics have established through studies analyzing terrestrial rivers with periodic or episodic discharge. This study aims to test whether the assumption of episodic thunderstorms on Titan is consistent with morphological characteristics of the valleys.

Radar Data: Cassini RADAR-SAR offer a large-scale spatial coverage at a resolution of up to 350m per pixel, appropriate to discern fluvial valleys. Recently, RADAR covers nearly one third of the surface of Titan with a nearly comprehensive coverage near the north pole and around the equator of the moon. Valleys appear either bright or dark in RADAR. Radar-bright surfaces are rough relating to the Radar-wavelengths of 2.17cm, presumably suggestive for dry riverbeds, whereas low radar reflectance point to smooth, probably liquid surfaces.

Flow patterns: Owing to their climatic background and discharge, terrestrial rivers are labeled as perennial, seasonal (intermittent) and episodic (ephemeral) rivers. Perennial streams have continuous flow due to constant rainfall in their catchments. Intermittent and ephemeral valleys are only seasonally or episodically filled. They are characterized by a shallow cross-section, anastomosing and braiding morphology. From terrestrial and Martian channels it is known that valleys with an ephemeral or episodic flow pattern evolve streamlined features and islands within the river bed [4]. The riverbanks are often subject to flooding.

Observations: Several valleys on Titan as imaged by RADAR have an ephemeral or episodic flow pattern. Figure 1 shows putative fluvial features located at

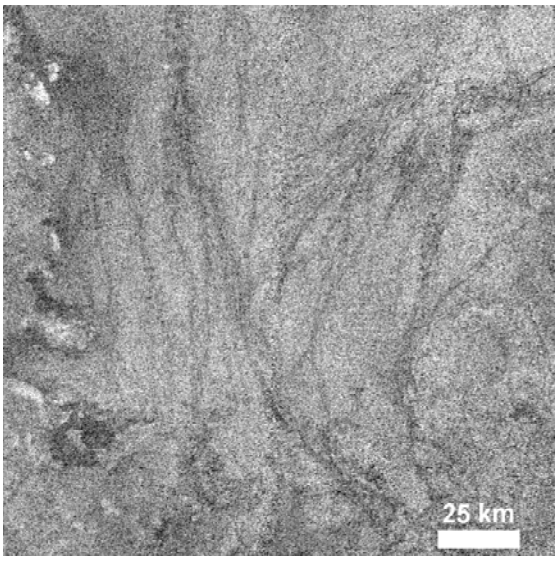

Fig. 1: Shallow channels or 'wadis' (Radar T7, 9/7/2005).

Titan's southern mid-latitudes. These features appear as a number of broad and possibly shallow valleys in dark-grey. The branches have a low sinuosity and are connected among each other. The valleys possibly represent an intermediate form between fluvial flow in valleys and surface runoff. The dark tone of the distributed channels compared to the surrounding terrain possibly indicates a layer of fine fluvial deposits [5].

Figure 2 illustrates examples of very broad valleys, that appear bright in RADAR. The unusual high radar returns of that channels are explained in [6] by the presence of rounded icy blocks. The catchment of the channels is located within a bright continent named Xanadu in the northern part of the image. As a terrestrial analog, Tagliamento River in northern Italy (see Fig. 3) flows from the Alps to the Adriatic Sea. Its hydrological regime is strongly seasonally determined by thunderstorm events, snow melt and low flow peri-

ods in between. Strong changes in water level follow, entailing a dynamic river system with large morphologic changes [7]. Both, the terrestrial rivers and channels on Titan in Fig. 2 and 3 appear bright and broadened, with a braiding morphology, thus implicating a similar development of the channels on Titan and Earth.

Active channels, that are recently filled with liquids, only appear near the north pole of Titan where they drain into large lakes, presumably filled with liquid hydrocarbons. The majority of Titan's valleys is not filled with liquids today. The predominance of dry valleys is a further argument supporting precipitation through thunderstorms followed by long dry periods.

Conclusions: RADAR images reveal several indications pointing to thunderstorm events that influence at least some of the fluvial valleys at the surface of Titan. Although the examples shown here are very diverse from a morphological standpoint, they underline a possible development of channels from thunderstorm events.

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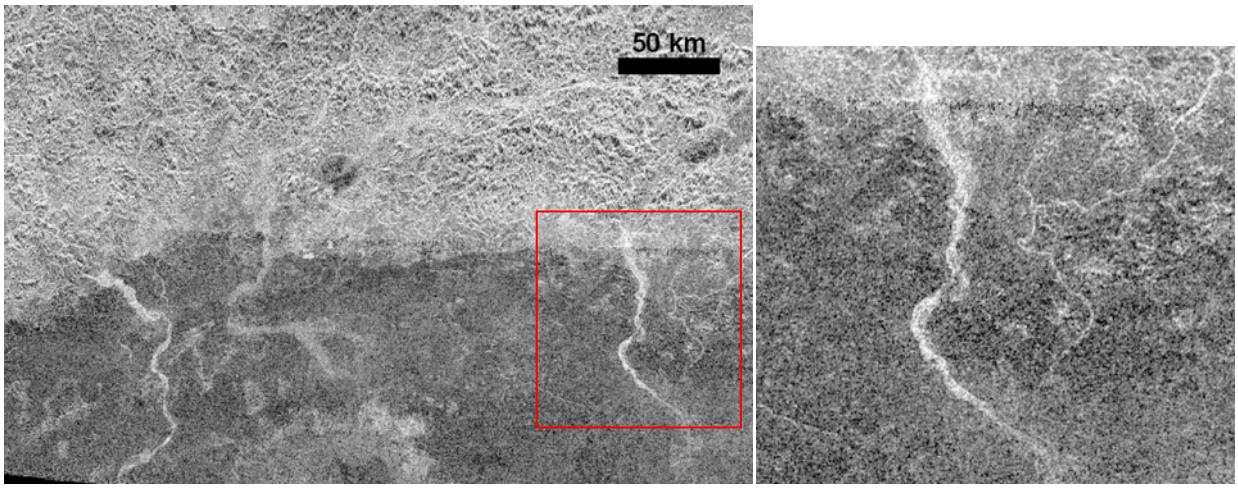

Fig. 2: Left: Broad channels south of Xanadu (Radar T44, 5/28/2008). Right: Detail of the eastern channel.

Fig. 3: Left: Tagliamento River, Italy (image source: Google Maps, 12/2009). Right: Zoom into the valley floor.