HIGH-VOLUME MEANDERING CHANNELS IN TITAN'S SOUTH POLAR REGION. M. Malaska[1], J. Radebaugh[2], A. Le Gall[3], K. Mitchell[3], R. Lopes[3], S. Wall[3]. [1]SCYNEXIS, Inc., P.O. Box 12878, Research Triangle Park, NC 27709-2878 mike.malaska@scynexis.com, [2]Brigham Young University, Provo, UT, [3]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA.

Introduction: In 2005, the Cassini ISS instrument detected a dark channel in Titan's south polar region [1]. This region was later examined in detail by the synthetic aperture RADAR (SAR) instrument during the T39 flyby [2] and revealed a terrain heavily dissected by fluvial and erosional processes [2,3,4,5,6]. In particular, a portion of the channel identified by ISS was observed to be part of a network of high-volume sinuous channels (Fig. 1).

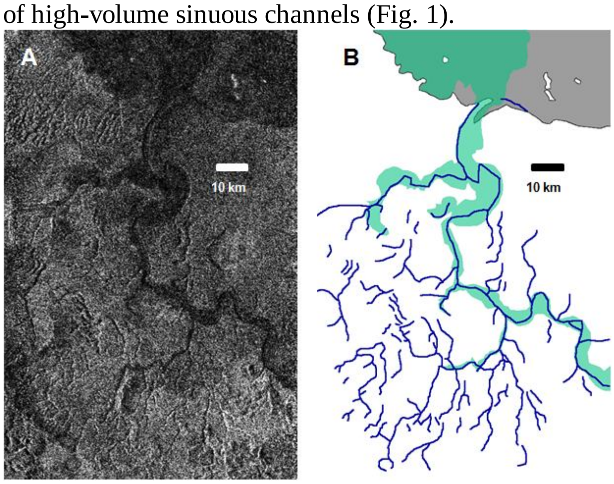


Fig.1: (A) Contrast-enhanced crop of T39 SAR Swath. (B) valley/channel trace. Grey region in upper NE corner is SW Mezzoramia. Green indicates RADAR darker regions. North is at top.

Study region and methods: A section of the T39 SAR swath centered near [-74 S, 33 W] was imported into Photoshop CS3 Extended, and the valley and channels were defined, traced, and measured as previously described [6,8]. In the northern part of the study region, a large high-order channel can be seen to enter SW Mezzoramia from the south. Upstream from this intersection, a large RADAR-dark kidney-shaped region can be discerned that has two sinuous RADAR-dark channels or canyons that enter from the West and the South, referred to in this abstract as the West Fork and South Fork Channels. Each channel fork contains some meanders that appear free of evident structural control and also display point bars on the convex side of this channel, indicating possible deposition. These unconfined meanders were measured using previously described methods to determine the average channel width (W), sinuosity (K), radius of curvature (R_c), meander wavelength (L_m), and meander belt width (B) [7].

West Fork Channel: This channel appears to drain the west end of an eroded upwarp[8] and consists of a wide RADAR-dark meandering stretch that then narrows significantly upstream after only a few meanders. The sinuosity of the meandering stretch was determined to be 1.31. Two of the meanders were selected for measurement, and the radius of curvature, wavelength and belt width were determined to be 3.2 km, 15.2 km, and 7.9 km, respectively. The average channel width is 4.0 km.

South Fork Channel: This channel enters from the eastern edge of the T39 SAR Swath as a wide RADAR-dark channel that flows to the NW where it undergoes several meanders, including a distinctive double-headed meander [9] that can be correlated to the ISS image. From the T39 swath edge to just before the kidney-shaped region, the sinuosity was measured to be 1.23. Five meanders in this stretch were selected for measurement and the average radius of curvature, meander wavelength, and meander belt width were determined to be 3.2 km, 20.3 km, and 8.2 km. The average channel width is 2.3 km.

Comparison with terrestrial rivers: The ratio of radius of curvature (R_c) and width (W) is considered a key ratio for terrestrial rivers [7]. When plotted againt a literature data set of terrestrial channels with a sinuosity > 1.2 [7], these two Titan channels fit the previously observed correlation (Fig. 2). When other empirically derived relationships for terrestrial channels are examined such as R_c vs. L_m, R_c vs. B, and L_m vs. B, the ratios are also close to their terrestrial analogs [7,10]. The noteable exception is that the observed widths of the Titan channels are larger than their terrestrial counterparts, although previous theoretical work has predicted that Titan channels should be 1.6 times wider due to the lower gravity [4]. The measured parameters for the two Titan channels are similar to those of high-volume terrestrial rivers. In both planform and measured values, the Titan South Channel is a close match to a stretch of the Mississippi River near Mayersville, MS. (Fig. 3)

Streamflow estimates for the Titan Channels: Using the previously determined relationship by Lorenz et al.[3] for bankfull discharge Q_{bf} (in m^3/s^{-1}) to meander wavelength L_m (assuming free meanders) for Titan channels: $Q_{bf} = 1.02\text{E-}5[L_m]^{2.174}$, the average discharge Q_{bf} for the West Fork Channel was determined to be 12,500 m^3s^{-1} and for the South Fork Channel 23,700 m^3s^{-1}. The formula derived by Jaumann et al.[4] (Q_{ave} = 0.0119 $W^{1.71}$) from measured channel widths, provided an estimated Q_{ave} of 16,600 m^3s^{-1} for the West Fork Channel and a Q_{ave} of 6,800 m^3s^{-1} for the South Fork Channel. The Q estimates are consistent with high-volume channels. For comparison, the Mississippi River Q_{ave} is 17,600 m^3s^{-1}.

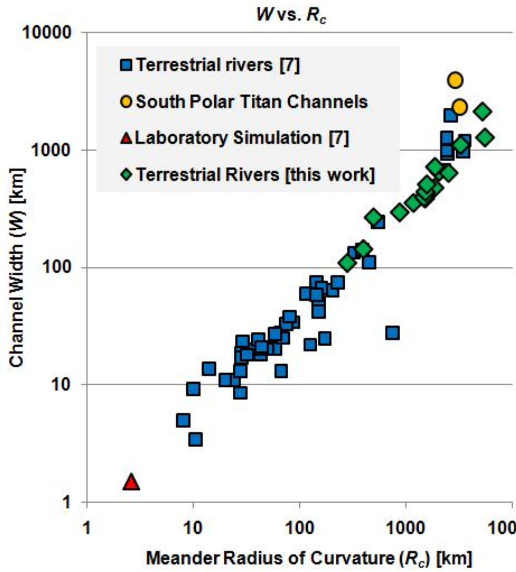
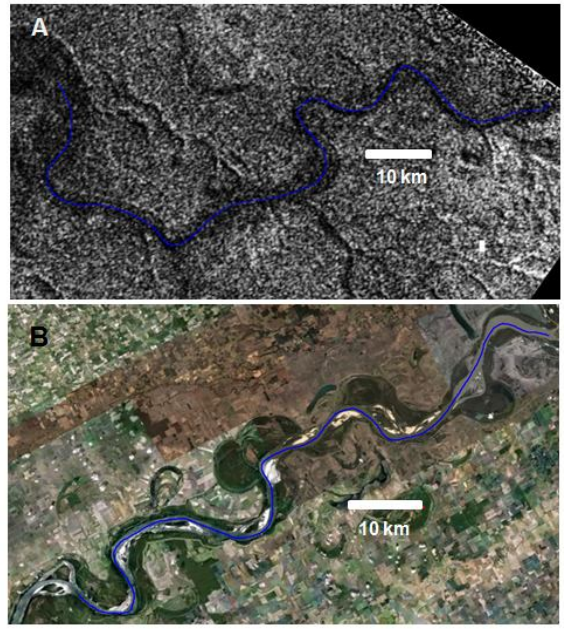


Fig. 2: Plot of channel width vs. meander radius of curvature for terrestrial channels and Titan West Fork and South Fork Channels

ISS correlation and possible seasonal changes: Alignment of the T39 SAR Swath and the corresponding ISS mosaics [1,11] reveals that the South Fork Channel is both ISS-dark and RADAR-dark. In the ISS image, the channel can be traced upstream where it crosses the eastern T39 boundary and curves back into the plain just south of Sikun Labyrinthus [6]. Comparison of ISS images taken in 2004 and 2005 reveals that two of the regions appear darker in 2005. Some of the changing darker zones in South Polar terrain had previously been described as transient lakes resulting from precipitation [11].

Estimated runoff production rate of region: The runoff production rate is given by $P=Q/A$ where A is the areal extent of the catchment area. Using channel traces to conservatively estimate drainage divides and taking the T39 Swath edges as a boundary gives an estimated drainage area (A) of 100,000 km^2. An estimated combined channel Q_{ave} of 30,000 m^3s^{-1} furnishes a production rate of 1.1 mm/hr. This is in line with previous estimates for rainfall production rates in diverse locations on Titan [3,4], although it is possible that these channels could be fed in whole or in part by subsurface seepage from a regional or global "methanofer" with recharge from a distant location.



	W Fork Titan Channel	S Fork Titan Channel	Mississippi River
Meander wavelength (L_m) [km]	15.2	20.3	15.9
Belt width (B) [km]	7.9	8.2	9.7
Radius of curvature (R_c) [km]	3.2	3.2	3.2
Sinuosity	1.31	1.23	1.42
Width (W) [km]	4	2.3	1.1

Fig. 3: (A) T39 SAR image of South Fork Titan Channel. (B) Google Earth image of Mississippi River near Mayersville, MS. In both images the channel midline is traced in blue. Streamflow is from right to left in both images. Table shows measured parameters.

Conclusions: Measurement of the meander and widths of two channels using Cassini RADAR data provides evidence for a high-volume drainage network on Titan. Morphometric parameters and derived ratios show that these channels have characteristics similar to high-volume terrestrial rivers. This provides an example of how channels made from different materials, conditions, and working fluids on two different planets can have similar morphological properties and relationships.

References: [1] Porco et al., *Nature* 434 (2005) 159-168. [2] Stofan et al., *LPS XXXIX* (2008), Abstract 1491. [3] Lorenz et al., *PSS* 56 (2008) 1132-1144. [4] Jaumann et al., *Icarus* 197 (2008) 526-538.. [5] Radebaugh et al., *DPS* 41 (2009) Abstract 36.07. [6] Malaska et al., *LPS XLI* (2010), Abstract 1544. [7] Williams, *Journal of Hydrology* 88 (1986) 147-164. [8] Malaska et al. *LPS XLII* (2011). [9] Charlton, R. Fundamentals of Fluvial Geomorphology, 2008, Routledge, New York, p. 142. [10] Ritter et al., Process Geomorphology, Fourth Ed., 2006, Waveland, Long Grove, Illinois, p. 217. [11] Turtle et al., *JGR* 36 (2009) L02204.