

**TITAN'S ELUSIVE LAKES ? : PROPERTIES AND CONTEXT OF DARK SPOTS IN CASSINI TA RADAR DATA.** R.D. Lorenz<sup>1</sup>, C. Elachi<sup>2</sup>, B. Stiles<sup>2</sup>, R. West<sup>2</sup>, M. Janssen<sup>2</sup>, R. Lopes<sup>2</sup>, E. Stofan<sup>3</sup>, F. Paganelli<sup>2</sup>, C. Wood<sup>4</sup>, R. Kirk<sup>5</sup>, J. Lunine<sup>1</sup>, S. Wall<sup>2</sup>, and the Cassini RADAR Team. <sup>1</sup>Lunar and Planetary Lab, University of Arizona, Tucson, AZ 85721-0092 (rlorenz@lpl.arizona.edu). <sup>2</sup>Jet Propulsion Lab, 4800 Oak Grove Dr., Pasadena, CA 91109. <sup>3</sup>Proxemy Research, PO Box 338, Rectortown, VA 20140. <sup>4</sup>Planetary Science Institute, Managua, Nicaragua Branch. <sup>5</sup>US Geological Survey, Flagstaff, AZ 86001.

**Introduction:** Titan's atmospheric methane abundance suggests the likelihood of a surface reservoir of methane and a surface sink for its photochemical products, which might also be predominantly liquid. Although large expanses of obvious hydrocarbon seas have not been unambiguously observed, a number of rather radar-dark spots up to ~30 km across are observed in the Synthetic Aperture Radar (SAR) data acquired during the Cassini TA encounter on October 26<sup>th</sup> 2004. Here we review the properties and setting of these dark spots to explore whether these may be hydrocarbon lakes.

**Instrument:** The CASSINI Titan RADAR Mapper is a multimode Ku-band (13.76 GHz) radar that uses Cassini's 4m high-gain antenna with a set of 5 separate antenna feeds. It is operated as a scatterometer or altimeter as a passive radiometer using only the central beam 3 (0.35° across) or, when within about 5000km of Titan's surface as a SAR with all 5 beams forming a fan (5.75x0.35°) Details are given in [1,2]

**SAR Data:** The TA SAR observation spans a northern midlatitude region from about 50N 75 W to 30 N 10 W. This region (poorly-illuminated in the present season) has not yet been observed in detail by Cassini's other instruments. A variety of features were detected, including a possible volcanic dome and a cryolava flow. Few if any impact craters were seen. Initial results are presented in [3].

Several particularly dark spots which may be deposits of organic materials, and in particular liquid hydrocarbons, can be seen in the SAR swath. Some appear in isolation, and are often faintly crescentic (ox-bow?) in shape. Others appear linked, as in the collection of features making up 'Si-Si the Halloween Cat'. Although there is nothing else in our data to support an impact origin, we are reminded that liquids would collect in topographic lows such as craters, and that impact features of this size on Titan would be expected to have central peaks (the simple-to-complex transition occurs at ~10km) and thus liquid-filled craters might well resemble rings or horseshoes [4].

Although dark regions may well be widespread in the radar image at the pixel scale (~300m), we focus our attention on 3 obvious dark spots, listed in table 1. The two smaller regions are shown in figures 1 and 3 : Si-Si is evident in web release PIA06984: 'Black Cat' on Titan. An additional feature is shown in figure 4.

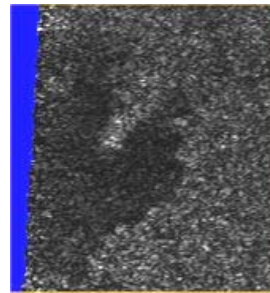


Fig1 – dark, crescentic area B at the southern edge of the SAR swath. Note bright 'peninsula'. Image is 20km across.

**Backscatter Properties:** Dark spots were isolated in the image and the estimated reflectivities extracted. These are uncorrected for incidence angle.

It can be seen (figure 2) that the reflectivities of these selected dark spots are quite distinct from the general population. The backscatter values (0.05~0.1 ; -13 to -10dB) are not untypical for dry, flat areas on Earth. We note that the backscatter is (albeit nonuniquely) consistent with asphalt surfaces, perhaps a not inappropriate analog for Titan.

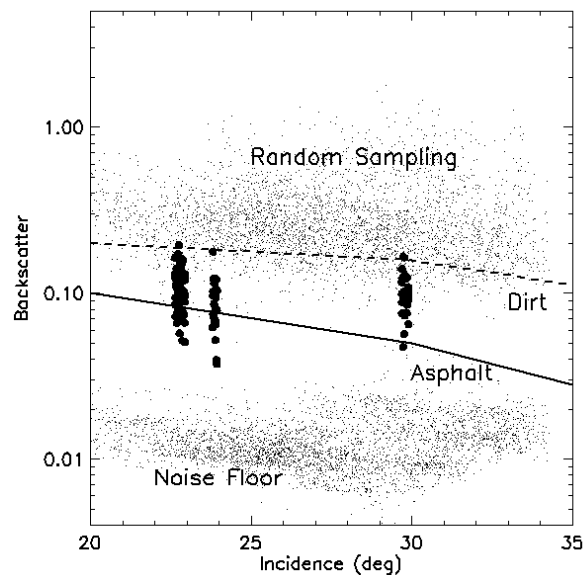


Figure 2. Radiometric properties of Dark Spots in table (filled circles, left to right regions B, Cat and A). These fall well outside (i.e. below) the typical backscatter seen in the swath (upper cloud of datapoints showing a random selection (1%) of 4x4 pixel averages from the whole SAR scene) but are well above the noise equivalent  $\sigma_0$  (lower cloud of points labeled 'noise floor'). Lines marked dirt and asphalt are means between data for 8.6 and 17 GHz HH backscatter coefficient given in [5].

Although rather darker than the rest of the scene, the dark spots are reliably detected – they are ~5dB brighter than the noise level. At present, the radiometric calibration of backscatter is estimated at +/- 2dB (i.e. \* or / by factor of 1.6)

**Passive Radiometry Data:** In the TA SAR swath, none of the contiguous dark spots were large enough to completely fill one of Cassini's 5 beams, and thus the radiometer data (which uses the real aperture of the antenna) does not sample dark material uniquely. However, radiometry 'pixels' in which dark spots occur (and fill about a third to a half) appear to be around 3K higher in brightness temperature, suggesting 'pure' dark material might increase the brightness temperature to around 90K. This implies a rather high emissivity, consistent with Fresnel reflectivities for dielectric constants of about 2. Further work is needed to understand the possible effects of scattering. If volume scatterers (or subsurface reflections) are present to increase reflectivity, the emission should be correspondingly decreased and the bulk material requires an even lower dielectric constant (1.6-1.9 is a range typical for liquid hydrocarbons) – see, e.g. [6].

**Scatterometry:** During the TA encounter, other areas of Titan were observed by RADAR in an active real-aperture scatterometer mode. Although these observations have much lower resolution (typically ~100km) they are made over a much larger range of incidence angles (0-60°) At least some areas had a moderate specular reflection at low incidence [3]. Remarkably, the backscatter remained near-constant at large incidence angles, suggesting volume scattering may be significant.

**Conclusions:** Dark spots, often shaped like arcs, appear in the TA SAR swath, and have radar backscatter and microwave emissivity apparently consistent with smooth hydrocarbon deposits. They occupy only a small fraction of the area of the swath

**References:** [1] Elachi, C., Im, E., Roth, L. E., and Werner, C. L.(1991), *Proc. IEEE*, 79, 867–880. [2] Elachi, C. et al. , *Space Science Reviews*, in press [3] Elachi, C. et al., *Science*, submitted [4] Lorenz, R. D., (1994) *Plan. Space Sci.* 42 1-4, 1994 [5] Ulaby, F. T., Moore R. K. and Fung, A. K., (1986) *Microwave Remote Sensing : Active and Passive Vol.3 From Theory to Applications*. p.1809 Artech House. (1997). [6] Lorenz, R. D., et al., (2003) *Plan. Space Sci.* 51, 353-364.

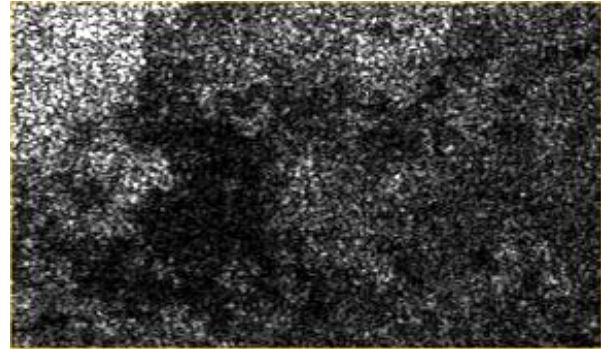


Figure 3. Dark region A. Note sinuous dark line to upper right. Image is 49x29km : dark spot is about 14km across

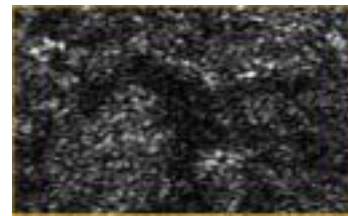


Figure 4. Additional dark crescentic spot about 10km across (near dark triangle in SAR swath)

Feature	$\sigma_0$	Inc (°)	W Lon (°)	Lat (°)
A	0.06-0.1	29.9	76.8	51.2
B	0.06-0.1	22.7	70.0	49.3
Cat	0.06-0.1	24.5	56.1	50.8

Table 1. Location of several 'dark spots'.

**Acknowledgements:** The observations reported here were made possible by the efforts of the Cassini RADAR Engineering Team as well as TOST and the Cassini project as a whole. The Cassini/Huygens mission is a joint endeavour of NASA, ESA and ASI.