**THE RAIN IN THE PLAIN ON TITAN.** P. A. Dalba,[1] B. J. Buratti[2], K. H. Baines[2] J. Barnes[3], R. H. Brown[4], R. N. Clark[5], P. D. Nicholson[6], C. Sotin[2]. [1]University of California at Berkeley, Department of Astronomy, Berkeley, CA 94720 (pauldalba@berkeley.edu). [2]NASA Jet Propulsion Laboratory, California Inst. of Technology, Mailstop 183-401, Pasadena, CA 91109 (Bonnie.J.Buratti@jpl.nasa.gov). [3]University of Idaho, Deparment of Physics, Moscow, ID 83844. [4]University of Arizona, Lunar and Planetary Lab., Tucson, AZ 85721. [5]USGS Denver, CO 80225. [6]Cornell University Department of Astronomy, Ithaca, NY 14853

**Introduction:** The surface of Titan is dominated by the methane cycle, similar to the water cycle that drives weather and erosion on Earth. Lakes, changing cloud systems that appear to be seasonally driven and extensive drainage patterns all suggest that rain should be falling on Titan. Good evidence for rain was presented by the *Cassini* Imaging Science Subsystem (ISS) camera based on observations obtained in 2010 [1]. Near the Huygens landing site, regions where clouds appeared on September 27 were darkened by Oct. 15, and then returned to normal. The most likely explanation for this pattern is rain originating from the clouds, which dampened and darkened the surface temporarily.

The ISS camera has several broadband filters including ones in the methane bands at 0.89 μm and 0.73μm However, the Visual infrared Mapping Spectrometer provides medium resolution spectra in the 0.35-5.1 μm spectral region. This is an area with several windows of clarity in Titan's methane atmosphere as well as much lower haze opacity than the visible region. Not only can changes in the albedo of the surface be observed and measured, but rudimentary compositional information, including temporal changes, can be detected. In this study we are seeking compositional changes that indicate the falling or evaporation of rain.

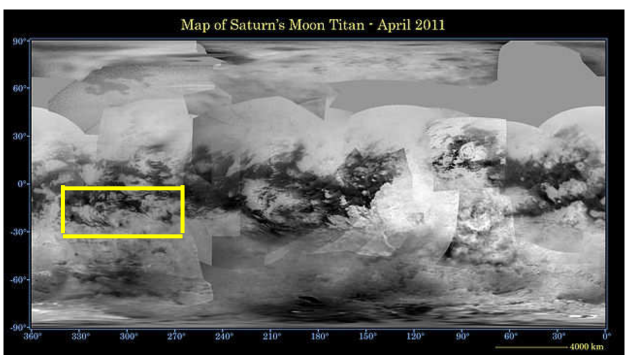


**Figure 1**: The area enclosed by the yellow square is a region of Titan that was imaged by the *Cassini* VIMS Instrument in both T61 and T76. In this study, spectral changes between the two flybys are sought.

**Observations:** The Cassini spacecraft executed two flybys in 2009 and 2011 that covered some of the same geographical regions. Table 1 is a summary of the geometrical circumstances of each flyby, which are known by the shorthand naming convention of T61 and T76 (the 61st and 76th flybys of Titan).

**Table 1 – Summaries of T61 and T76**

| Orbit | Flyby | Date | Approach Distance | Main Instrument | VIMS Data |
|---|---|---|---|---|---|
| 117 | T61 | 8/25/09 | 961 km | Radar | ~Hour outside C/A |
| 148 | T76 | 5/08/11 | 1873 km | VIMS | At closest approach |

Figure 1 shows a location on a base map of Titan that was closely scrutinized in both flybys. Seven regions were selected from the left side of the area enscribed by the yellow for detailed before-and-after spectral analysis. The seven regions are shown in Figure 2.

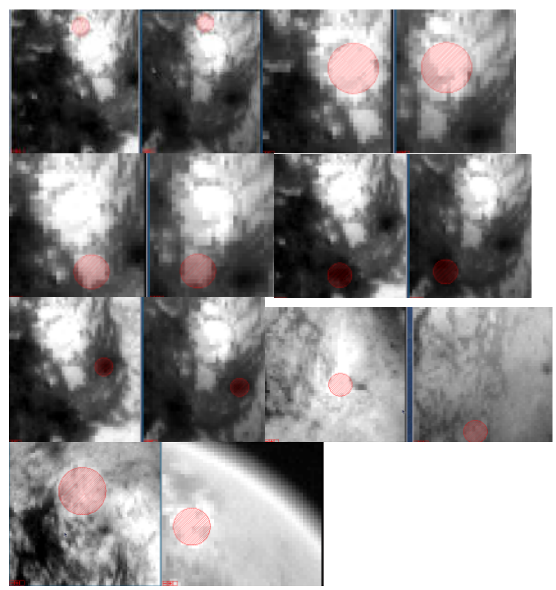

**Figure 2:** The seven pairs of regions selected from the left side of the yellow reactangle for before-and-after spectral analysis. The region from T61 is shown on the left and the same region from T76 is shown on the right. Each of the seven pairs of images shows the region (in red) from which an average spectrum was computed. (These images are rotated about 90º from the basemap)

An average spectrum between 0.85 μm and 5.1 μm was computed in each of the seven pairs of images. In order to detect spectral changes, the spectra need to be ratioed. However, the path length through the atmosphere changes between the two flybys. To correct for this problem, we first ratioed the spectra to "standard areas", which are regions in each flyby which have nearly the same albedo and path length. Each of these corrected pairs of spectra were then ratioed.

**Results and Discussion:** We found no changes in areas 1-5. However, we detected substantial changes between T61 and T76 for regions 6 and 7. Figure 3 shows the spectral ratios for Region 6. The dips in the spectra at 2 μm and 5 μm are consistent with liquid methane being present on the surface of Titan during T76 but not during T61 [2]. The most likely explanation for this observation is the deposition of liquid ethane on the surface from a rainstorm that occurred between the two flybys.

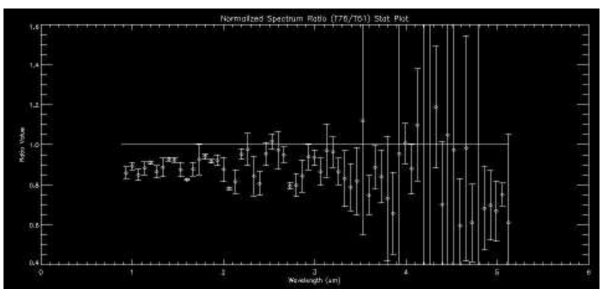

**Figure 3.** The ratio of the I/F spectra from T61 and T76 for region 6 (the right pair of images on the third row in Figure 2).

Figure 4 shows the results from our analysis of region 7 (the last pair of images in Figure 2). This region shows the exact opposition situation: The ratio is consistent with the evaporation of liquid ethane (or another hydrocarbon with a similar spectrum). This result suggests that there were both deposition and evaporation of ethane between the two flybys.

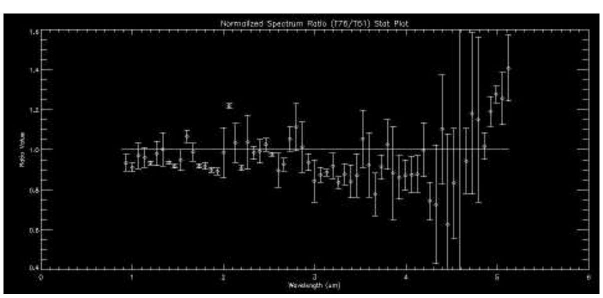

**Figure 4.** The ratio of the I/F spectra from T61 and T76 for region 7 (the last pair of images in Figure 2).

Our work suggests the possibility that there are scattered and numerous rain showers on Titan. Between T61 and T76, one rainstorm (in region 6) occurred and wetted the ground with a liquid hydrocarbon. But a previous rainstorm, which had moistened area 7 prior to the T61 flyby, had dried up in the same interim. Other explanations are possible. For example, a surface dampened by ethane or another hydrocarbon could have been covered by a different process such as the accumulation of blowing dust. In this scenario, part of the region affected by a more widespread rainstorm was covered by a dust storm.

**References:** [1] Turtle, E. P. et al. (2011) *Science* **331**, 1414. [2] Brown, R. H. et al. (2009) *Nature* **454**, 607.

**Ackowledgements:** This research was carried out at the Jet Propulsion Laboratory, California Institute of Technology under contract to the National Aeronautics and Space Administration. 