Pit Distribution in Titan's Equatorial Region. Kimberly Adams and Donna M. Jurdy, Northwestern University, Department of Earth and Planetary Sciences, Evanston, IL 60208 (kadams@earth.northwestern.edu).

Introduction: Cassini's Radar [1,2] imaged the surface of Titan through its thick atmosphere. Using the synthetic aperature (SAR) mode at 13.78 GHz we can see several geologically interesting features on the surface. On October 27, 2005 Cassini made the T8 fly-by with a range of 7.2 degrees north to -18.6 degrees south and 179.1 to 320.3 degrees west. The T8 image, used in this study, has a resolution of 1.75 km/pixel (256 pixels/degree). In this image we can see small pits [3], in the eastern portion of the T8 image, between two mountains [4]. The pits range in size up to 2 km in diameter. Pits on Titan may be associated with cryovolcanism and could be caused by explosions of methane beneath the surface [3]. Originally over 150 pits were mapped in the equatorial region [3], but we initially found only 109 pits (Fig. 1). We examine the distribution of these pits by doing a chi-squared analysis as well as a fractal analysis to determine any patterns that may exist.

Chi-Squared Analysis: We concentrate our initial analysis on the eastern portion of the T8 swath between the mountains where most of the pits are located. Chi-squared analyses were used to assess the randomness of pit distribution. Breaking this portion of the T8 swath into smaller sections makes the geometry of the swath suitable for chi-squared analyses, and reduces the effect of missing data (Fig. 1). Each of the three sections is then split into equal-area boxes, and the pits in each are counted.

We use the equation:

$$X^2 = \sum (O_k - E_k)/E_k$$

for chi-squared (where O_k is the number of pits in the box and E_k is the average number of pits in the area) [6]. A reduced chi-squared value can be found by dividing by the degrees of freedom (d).

Clustering of the pits is obvious from the discrepancy in the pit count between boxes (Fig. 1). We use chi-squared analyses to assess the likelihood of this occurrence. The yellow area in Fig. 1 showed a reduced chi-squared value of 2.29, corresponding to a 2.9% chance of being random. The green area shows a reduced chi-squared of 2.6, a 4% chance of being random. Finally, the red area with a reduced chi-squared value of 7.65 has only a 0.05% chance of occurring with a random distribution. Thus none of these distributions is likely to be random.

We also performed a chi-squared analyses of the most obvious cluster, in the lower right hand corner of Fig. 1. The reduced chi-squared value for the cluster is 0.59, a 75% chance of being a random distribution. This suggests that the distribution within a cluster is random.

Fractal Analysis: Fractal analysis of the pits allows us to make another comparison of the distribution of pits to a random distribution. By starting at the center of longitude and latitude of the pits, and expanding with a concentric pattern out from that point, pits can be counted per area fraction [7]. A random distribution of points would increase linearly with increasing area.

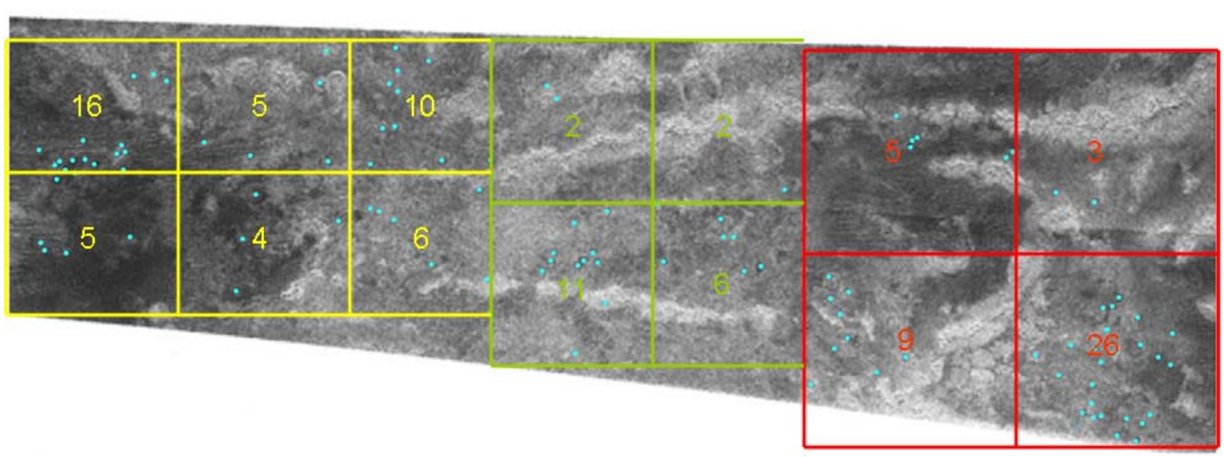

Fig 1: *Portion of T8 is split into three regions (yellow, green, red) for chi-squared analysis. Each region is split into equal areas and pits are counted in each, represented by the number in each box. (Pits in blue)*

The cumulative distribution of our counted set of 109 pits, as well as a log-log plot, was compared to a random distribution of 109 pits in the same area. As can be seen from Fig. 2, which compares the cumulative distributions, distributions differ by almost two standard deviations. These differences are attributed to the clustering the pits appear to exhibit.

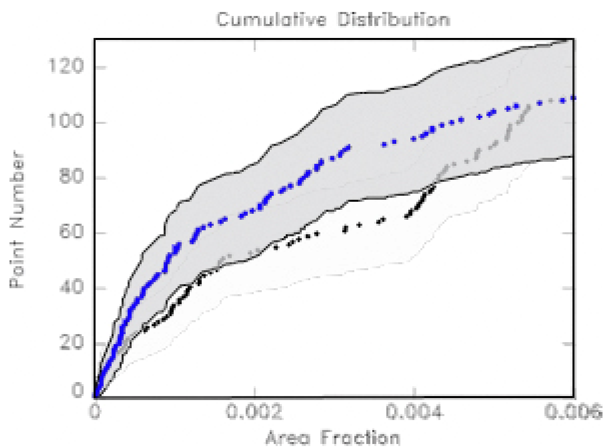

Fig 2: C*omparing the fractal analysis for pits in the T8 image of Titan (black) and a random distribution of points (blue) over the same area. The shaded area represents the uncertainty, two standard deviations (2√N).*

To further study the distribution within a cluster we analyzed the same cluster studied in the chi-squared analyses. We compared the fractal analyses in this area to a random distribution of pits in the same area (Fig. 3). The results showed that the distribution of pits within a cluster appear to be random.

Conclusions: Both chi-squared and fractal analysis show that the distribution of pits in the eastern portion of the T8 swath of Titan is not random and appears to exhibit clustering. However, within the southeastern cluster of pits the distribution does appear to be random. It is possible that the pits could be related to the linear mountain features seen in the image. Crustal extension offers one explanation for the mountains, similar to the Basin and Range of the southwest United States [4]. Possibly, when the mountains formed, destabilized methane clathrates exploded to the surface forming pits.

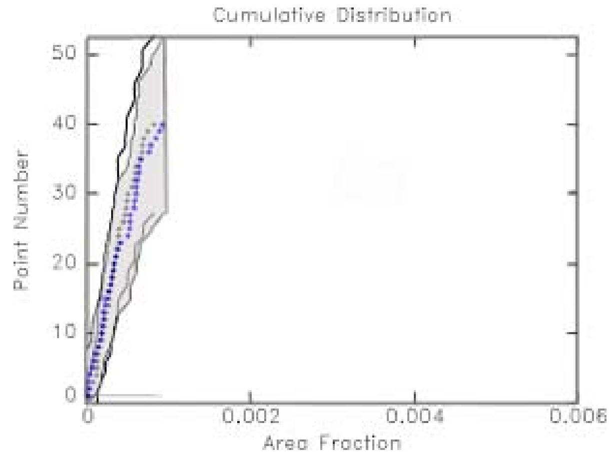

Fig 3: C*omparing the fractal analysis for pits in the T8 image of Titan (black) and a random distribution of points (blue) in the cluster seen in the lower right hand corner of the study area. The shaded area represents the uncertainty, two standard deviations (2√N).*

Future Work: Further study of the pattern of pits will be performed after recounting the pits. During the recount we will attempt to assess the diameters and perform a study of the pit size distribution. Pits on Earth, Venus and Mars commonly occur in chains [8], therefore an expanded fractal analysis to establish whether pits show any linear trends will be undertaken. We will also be examining the pit distribution in the available swaths of Titan to establish whether pits are localized in the equatorial region and are associated with any other mountain chains. A characterization of the pit distribution could lead to the development of a model for pit formation.

References:

[1] Elachi C. et al. (1991) *Preoceedings of the IEEE, 79,* 867–880. [2] Elachi C. et al. (2004) *Space Science Reviews., 115,* 71-110. [3] Lopes R. et al. (2007) *Icarus, 186*, 395–412. [4] Radebaugh J. (2007) *Icarus, 192*, 77–99. [5] Jurdy D. M. and Stefanick M. (1990) *GRL, 17,* 1965-1968 [6] Taylor J. R. (1997) An Introduction to Error Analysis, 266 [7] Feder, J. (1988) Fractals [8] Wyrick D. et al. (2004) *JGR, 109,* E06005