THE CASE OF TITAN'S MYSTERIOUS NEW ISLAND: ANALYSIS OF ANOMALOUSLY BRIGHT FEATURES OBSERVED IN THE CASSINI T92 SAR PASS OVER TITAN'S LIGEIA MARE.

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Introduction: Anomalous, bright features were detected in Titan's north polar Ligeia Mare, during the Cassini T91 and T92 RADAR passes in May and July of 2013 (Fig. 1). The anomalous features were not detected in preceding nor subsequent RADAR and Visual and Infrared Mapping Spectrometer (VIMS) observations. Similarly sized peninsulas of the nearby land mass (bright region at the top right in the panels of Fig. 1) however were consistently detected in all of these observations. The T91 image has noticeably more speckle and lower resolution because it is constructed from range-Doppler processed, real aperture data rather than synthetic aperture RADAR (SAR) data. The RADAR backscatter from the region of the anomalous features in the T91 observation was above the noise.

Hypotheses: Hypotheses to explain the anomalous features can be organized into three broad categories:

1. The features are artifacts in the SAR data and are not physical,
2. The features are perennial and their detection depends on the geometry of the observation,
3. The features are ephemeral and their detection depends on the timing of the observation.

Analysis: Common SAR image artifacts include ambiguities, scalloping, gain control problems, and edge effects. Ambiguities can result in the ghost of a bright target appearing offset in range and/or azimuth. Range ambiguities occur when the RADAR instrument receives overlapping returns in the time domain from adjacent echo pulses while azimuth ambiguities arise from aliasing in the frequency domain of an echo. An investigation by the Cassini RADAR team found that there are no bright targets in the vicinity of the anomalous features that could result in range or azimuth ambiguities. Nadir ambiguities, scalloping, and gain control effects are unlikely to create anomalies that are as spatially confined as the observed features. The dark pixels surrounding the anomalous features indicate that they are not the result of an edge effect. Thus standard SAR image artifacts are not a viable explanation for these features.

The geometry of the RADAR observations is primarily described by the angle of incidence. Fig. 2 is a plot of the normalized RADAR cross section from the region of the anomalous features as a function of incidence angle. Only the T91 and T92 observations at 4 and 6 degrees incidence respectively (black points) measured returns above the noise floor (blue arrow heads). Thus any model that explains the anomalous features as permanent, static structures must be consistent with the two detections and stay below the noise values at higher incidence angles where the anomalous

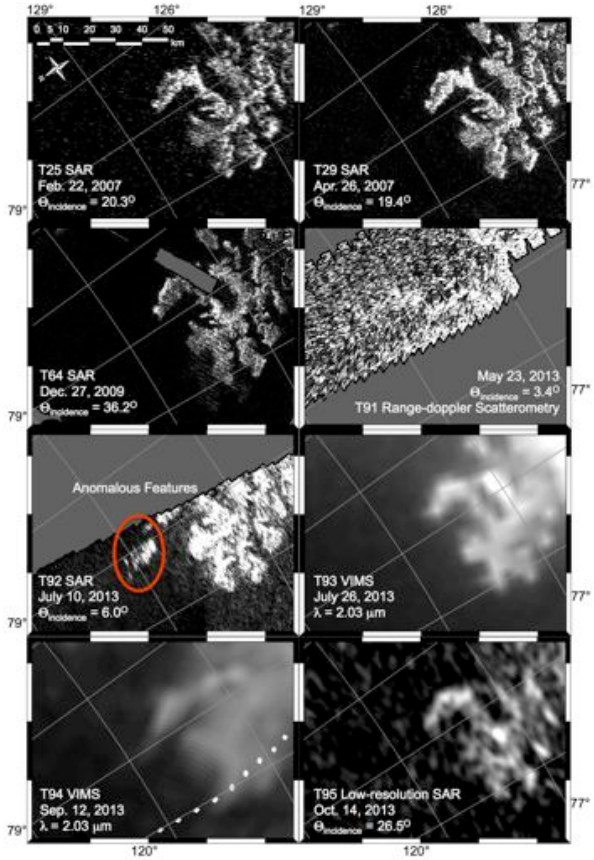

Figure 1: The eight Cassini passes that imaged the relevant region. In the T92 image, anomalously bright features (circled in red) are observed that are not seen in any of the other SAR images nor either of the VIMS images.

features were not detected (otherwise, the anomalous features would have been detected in those passes). We considered three classes of quasi-specular (QS) models: exponential, Gaussian, and Hagfors. To test if the data are consistent with QS models, we simulated both detections by randomly generating backscatter values such that they followed a normal distribution, with the mean and standard deviation given by the observed backscatter and error. We then checked if any QS models fit the two simulated backscatter measurements and remained below the upper limits at higher incidence angles. Quasi-specular models failed to fit the data in 88% of the simulations (99.75, 88, and >99.99 respectively). The mean parameters of the successful models are given in the legend of Fig. 2 and models with these parameters are also plotted in the figure. We note that the upper limits at incidence angles greater than 20^o do not permit the anomalous features to have any appreciable, diffuse scattering component. All of the major, solid terrain classes on Titan however exhibit both quasi-specular and diffuse scattering [1].

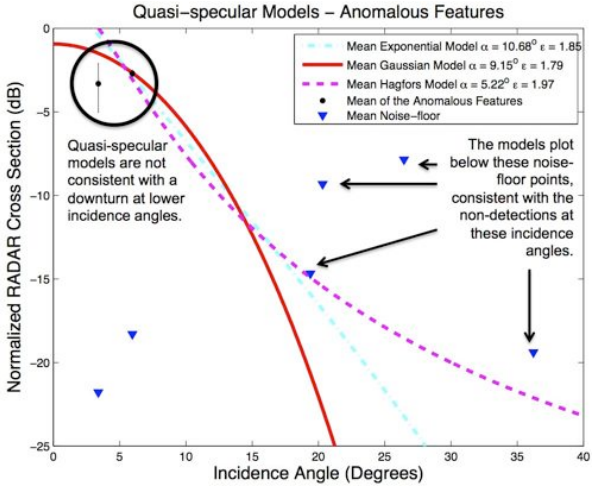

Figure 2: Normalized RADAR cross section of the region of the anomalous features as a function of incidence angle. Only the T91 and T92 observations at 4 and 6 degrees incidence respectively (black points) measured returns above the noise (blue arrow heads). To 88% confidence, exponential, Gaussian, and Hagfors models are not consistent with the observations.

We also modeled the anomalous features as submerged scatterers beneath the sea surface (using constraints on the sea surface roughness and dielectric constant from another observation [2]) and found similar results. As a check on our analysis procedure, we analyzed one of the nearby peninsulas in a similar manner. The results (shown in Fig. 3) were consistent with other terrains on Titan [1], providing confidence that the analysis procedure does not introduce a bias that is responsible for the inability of QS models to explain the anomalous features.

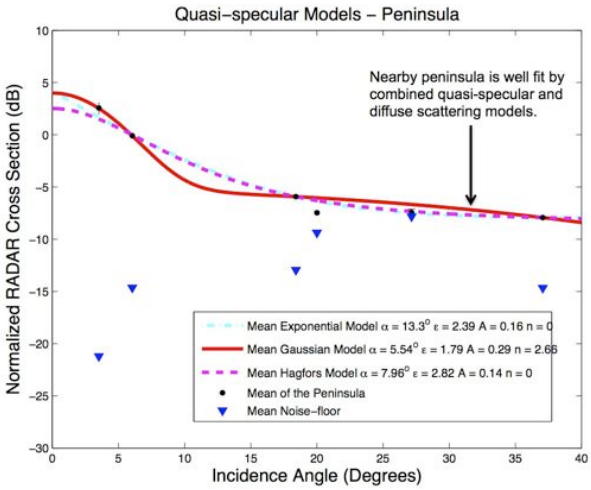

Figure 3: Normalized RADAR cross section of a peninsula near the anomalous features as a function of incidence angle. The peninsula is well fit by combined quasi-specular and diffuse scattering models, providing confidence that the analysis procedure does not introduce a bias that is responsible for the poor fit of these models to the anomalous features.

Conclusions: Anomalous, bright features were detected during the Cassini T91 and T92 passes over Titan's north polar Ligeia Mare. These features were not detected in any preceding nor subsequent observations. SAR image artifacts are not viable explanations for the observed features. The anomalous features can not have any appreciable diffuse scattering and to 88% confidence can not be fit by quasi-specular models. These results indicate that the anomalous features are either unique on Titan or transient in nature.

Future Directions: The next stage of the analysis is to constrain the possible transient hypotheses for the anomalous features. Cassini's T104 pass in August 2014 will provide additional constraints on the physical characteristics of these enigmatic features.

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References: [1] Wye L. (2011) RADAR Scattering from Titan and Saturn's Icy Satellites Using the Cassini Spacecraft. [2] Mastrogiuseppe M. *et al.,* (2013) in press.