**Introduction:** Saturn’s largest moon Titan is the second known solar system body on which standing bodies liquid are maintained, the first being Earth. Under Titan’s current climatic conditions, stable surface liquids (predominantly a methane-ethane-nitrogen ternary mixture) are restricted to the polar regions [1,2]. There, liquids pond within two distinct type of depressions: open basins like Kraken Mare or Jingpo Lacus, where evaporation/infiltation is counter-balanced by surface runoff. These larger basins appear to have developed through inundation of a preexisting well-drained landscape, and their formation is relatively straightforward.

The remainder of liquids are contained within sharp edged depressions (SEDs) form topographically closed depressions with no evidence, at the 300 m resolution of SAR images, of terrain features that would suggest inflow or outflow of fluid on the surface, and presumably retain a filled state via subsurface infiltration [1]. SAR images have shown that SEDs are found throughout both polar regions [2], and show no obvious planview orientation or spatial patterns. Further, the floors of many SEDs are relatively smooth, while the curvature of their perimeters is consistent with growth via uniform scarp retreat [3]. Compared to the larger seas, SED formation is poorly understood. New topographic data, however, is now allowing for more detailed studies of their 3-dimensional forms [3], and permits more detailed models of formation.

Dissolution of a soluble substrate, as noted in previous studies of Titan’s SEDs [4,5], can successfully explain all the above observations, and remains a particularly attractive model for their formation. However, new topographic data has revealed the presence of hundred-meter high raised rims around the perimeters of a subset of these features that defy explanation [3], and add serious complications that cannot be explained by dissolution erosion alone. Here, we perform a comprehensive study of the rims of Titan’s SEDs using a combination of SAR image, and high-resolution topographic data.

**Rim Identification:** Cassini topographic data is available through 3 different processes [6], with the altimeter being the most useful because of its order-of-magnitude better vertical (<35 m) resolution. This resolution is further increased by another factor of ~2 through delay-doppler processing of the returned signal [7], providing the best possible topographic data on Titan available from the Cassini mission. For the 8 flybys where Cassini acquired altimetry data over the polar regions, we can thus compare directly these topographic profiles to the SAR images. Specifically, the T30, T91, and T126 profiles all crossed one or more SEDs and thus allowed us to investigate the topographic profiles of these features in the highest detail possible. For the 15 SEDs that had a topographic profile, all but 2 had elevated rims. For many of these, a peculiar pattern also appeared, where the elevated portion repeatedly exhibits a distinctive bright-dark pairing, suggestive of elevated topography (Figure 1).

The high probability, albeit with a limited sample size, of SEDs with rims in topographic data, along with the repeated correlation of elevated topography with a visible feature necessitated an inspection of the remainder of Titan’s SEDs. To do this, and remain confident that identified features are in fact real, we restricted ourselves to SEDs that have been imaged at least twice from different azimuth and/or incidence angles. By using multiple images, of the same SED, and at differing viewing geometries, we can observe how the bright-dark pairing changes.

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**Figure 1:** (top) T91 SAR image of an un-named SED with the bi-secting altimetry topographic profile over-plotted. The parallel yellow lines denote the limit of the 3 dB footprint. The blue arrows denote the raised rim as observed in the SAR image; (bottom) Delay-doppler processed T126 altimetry profile showing rims elevated ~250 meters above the surrounding terrain outside the SED. “a” and “a’” denote the start and end of the track shown in the top panel.
For example, if we look at the same SED from two opposing azimuth angles (180° different), then the bright-dark pairing should invert itself. Similarly, for higher incidence angle observations, the pattern should differ from more nadir observations. For high incidence angle observations, the returned power from the leeward side (closer to the spacecraft) of a rim should be relatively high compared to a more nadir observation, where a rim is less obvious.

Therefore, if a given feature appears exactly same even though viewing geometries change drastically, then we conclude that the given SED does not have a rim. The opposite is true if the bright-dark pairing does change. For intermediate cases, where geometries are similar, the pattern should remain self-consistent, in which case we also conclude that a SED has a rim.

Rim Validation: Our first confirmation that indeed the rims we identified were elevated features came in visual comparisons to Titan’s equatorial dunes (Figure 2). Commonly, the dunes show an enhanced brightness when the azimuth angle is near-perpendicular to the crests of the linear dunes. This pattern, that we believe hold true for the rims when the azimuth angle is near-perpendicular to the crests of the linear dunes.

This pattern, that we believe hold true for the rims as well, is not the result of shadowing, but instead due to the high slope of a local surface feature. If the slope is comparable to the incidence angle of the SAR observation, and the azimuth angle is close to perpendicular to the local dune crest, then the power returned to the spacecraft will be as if the spacecraft was looking at a flat surface at nadir. This power can be many dB higher than if off-nadir, as seen when observing the seas in altimetry mode, and can easily manifest itself as an enhanced return in the SAR image, which assumes a flat surface. As the delay-doppler processed altimetry shows that local surface slopes of rims are in excess of 45° [3], we suspect that the same process is occurring.

Our second test will follow on this visual inspection, where we are in the midst of creating a realistic SAR model of the surface. This final test will quantitatively compare the observed brightness contrast, as a function of both incidence and azimuth angles, between the two sides of a rim using measured topographic profiles and realistic scattering models as inputs.

Rim Statistics: Using the criterion described above, we found 191 SEDs that were covered by multiple SAR swaths with varying viewing geometries. This represents ~30% of Titan’s north polar SEDs [2]. Of these, ~75% have an observable rims, with a preference for larger SEDs to have more observable (larger) rims (Figure 3). This pattern is consistent with the altimetry statistics, indicating that most SEDs have rims, and that rims may be constructional (i.e. rims grow with SEDs).