Specular Reflections from Titan's Punga Mare Seen by *Cassini* VIMS Indicate Surface Roughness: Waves?

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Abstract's Abstract

Cassini/VIMS T85 observations of Titan's north pole show significant specular return from parts of Punga Mare consistent with 6°-slope waves.

Abstract

Observations of Titan's north pole from the Visual and Infrared Mapping Spectrometer (VIMS) aboard the *Cassini* spacecraft have previously seen specular reflections of the Sun at the specular point on the moon's surface [1, 2, 3, 4]. We show the T85 (2012 July 24) observation in Figure 1.

Figure 1: *Cassini*/VIMS image CM_1721848119_1, acquired on the T85 flyby 2012 July 24 from a range of ∼ 30000 km. This image has colors mapped with 5 μm as red, 2.8 μm as green, and 2.0 μm as blue. The nature of the brightest specular return, from Kivu Lacus, is discussed in [4].

Low-incidence, low-emission angle observations of Titan's north polar regions on T93/T94 (2013 July 26 and 2013 September 12 repsectively) provide new insight into the specular reflection from T85. Figure 3 shows a north-polar orthographic projection of T94 (upper-left) with T85 (upper-right and lower-left) along with an outline showing the locations of surface liquid (lower-right). First, note that all of the illuminated lakes and seas in the T85 observation are *brighter* than their surroundings due to specular reflections of the (somewhat) bright Titan sky at 5 μm. Four distinct pixels within Punga Mare, indicated by blue arrows in Figure 2, show unusally high flux confirmed to be specular in nature by the full spectrum.

We develop a model to interpret these four points as wavy seas reflecting the Sun away from the specular point due to their slopes. Although we cannot rule out mudflats covered in a liquid layer as the source of these slopes, our best-fit value indicates slopes of $6° \pm 1°$ (Figure 3). If the roughness is indeed due to waves, then the implied winds are 0.76 ± 0.09 m/s and the waves themselves should be 2^{+2}_{-1} cm in height (Figure 4.

If correct this discovery represents the first sea-surface waves known outside of Earth. That they have previously been undetected and are now evident is consistent with the Lorenz et al. [5] hypothesis that winds had previously been low due to seasonal cycles but are picking up as northern spring develops.

References

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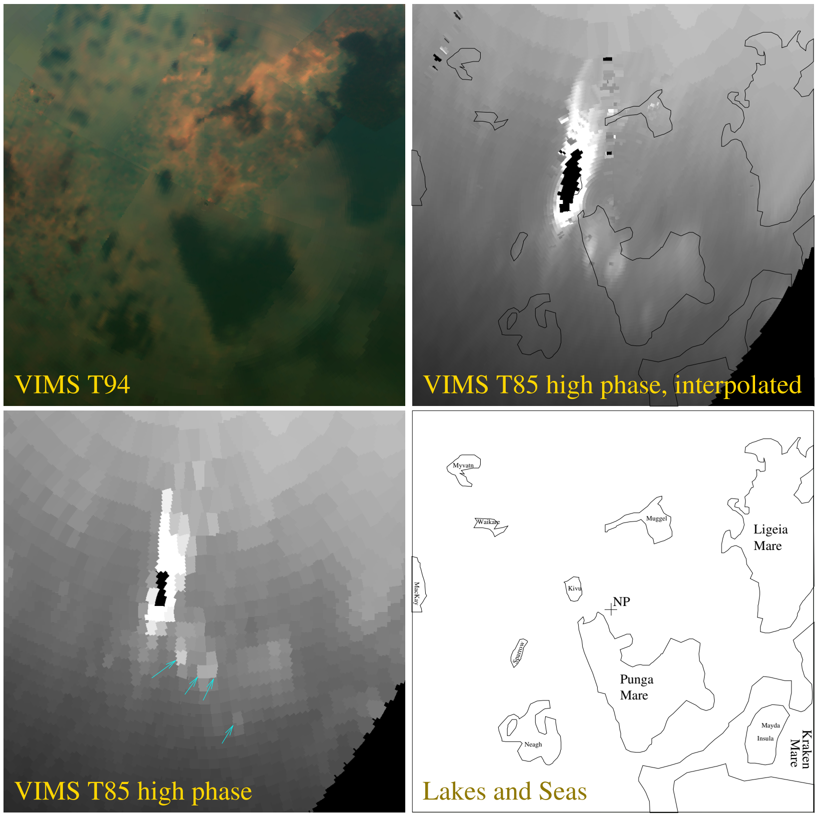

Figure 2: Views of the north pole of Titan from T94 (upper-left) and at high phase at 5 μm wavelength on T85 (upper-right and lower-left). The seas are brighter than the land due to specular reflections of the bright sky. We interpret the areas indicated by the blue arrows at lower-left as possibly wavy patches within Punga Mare.

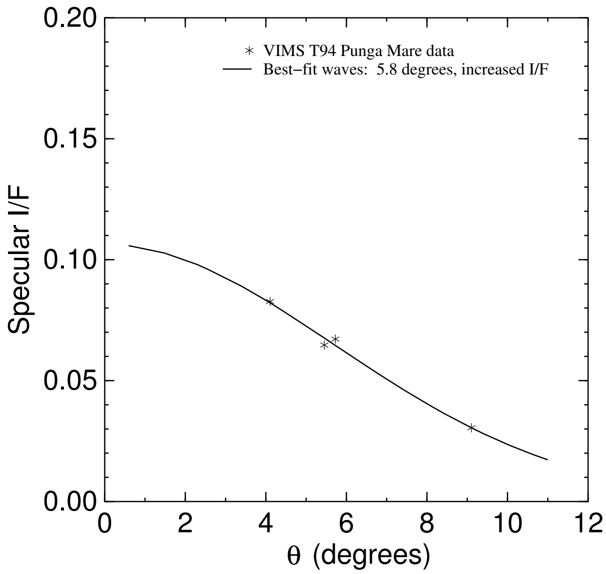

Figure 3: Best-fit line modeling the four rough specular pixels within Punga Mare indicates waves with RMS slopes of $6° \pm 1°$.

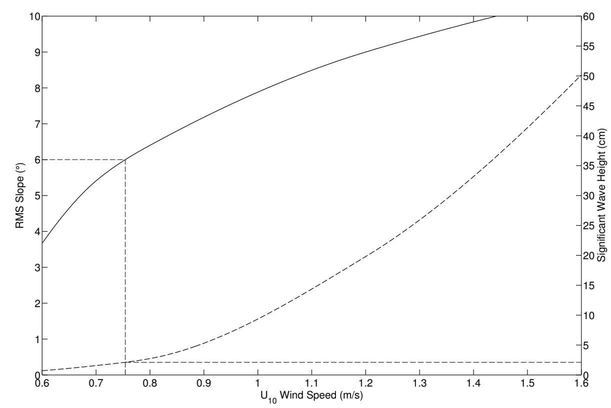

Figure 4: Mean slope and significant wave height on Titan as a function of wind speed, as derived from models [6, 7].