TRANSIENT BROAD SPECULAR REFLECTIONS FROM TITAN'S NORTH POLE

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Introduction: The recent *Cassini* VIMS (Visual and Infrared Mapping Spectrometer) T120 observation of Titan show extensive north polar surface features which might correspond to a broad, off-specular reflection from a wet, rough, solid surface. The observation appears similar in spectral nature to previous specular reflection observations and also has the appropriate geometry. Figure 1 illustrates the geometry of specular reflection from Jingpo Lacus [1], waves from Punga Mare [2] and T120 observation of broad off-specular reflection from land surfaces. We observe specular reflections apart from the observation of broad specular reflection and extensive clouds in the T120 flyby.

Our initial mapping shows that the off-specular reflections occur only over land surfaces. This could be plausible evidence for rainfall on Titan's surface. Accordingly, these observations are referred to as 'wet sidewalk effect' [2]. We have used the broad specular reflections in conjunction with the distribution of clouds in that area, using *Cassini* VIMS T120 flyby, to evaluate whether the observations could be consistent with recent *rainfall-wetted* surfaces. At the same time we are actively considering alternative hypotheses such as a mudflat [3], mirage, low-lying clouds or other lower atmospheric phenomenon.

Objectives: The objectives of this study are to:
1) Provide the spatial context for the specular regions, off-specular regions, and the clouds in the T120 flyby. This would aid in determining the origin of the off-specular reflections which correspond to solid land.
2) Determine and evaluate the spectral character of regions corresponding to the broad specular reflection using *Cassini* VIMS.
3) Model this off-specular reflection phenomenon in a SRTC++ (Spherical Radiative Transfer in C++) code (currently in progress).
4) Study the brightness change over time for the off-specular pixels. Any brightness change in the remaining Cassini flybys of Titan's North pole (post T120) might indicate subsequent change in the surface properties of those regions .

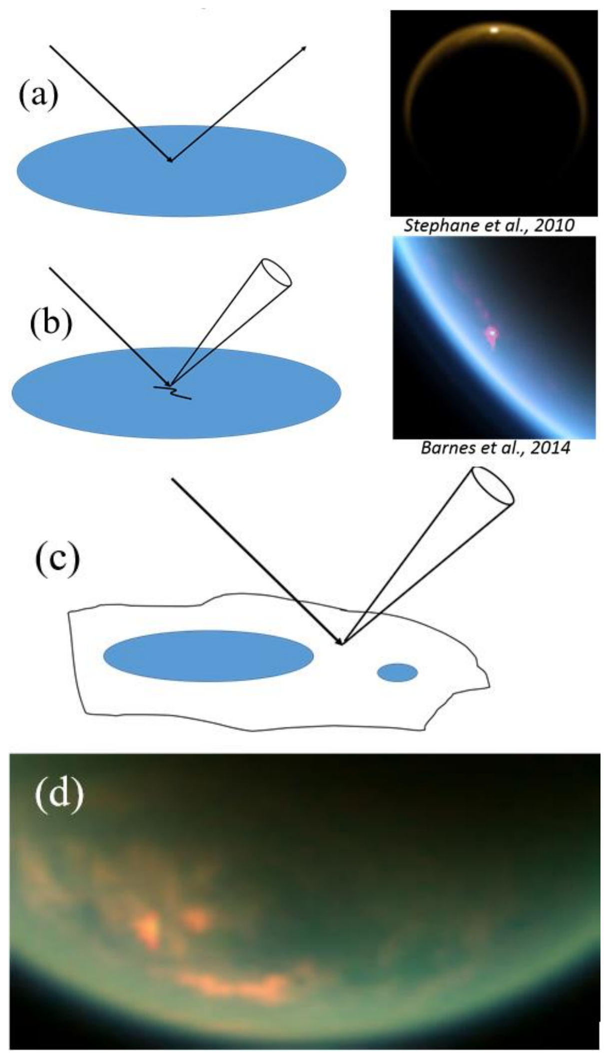

Figure 1 (a) illustrates the specular reflection [1] observed from Jingpo Lacus at the North Pole of Titan. (b) illustrates the waves observed in Punga Mare as a reflection in the form of a lambertian cone from the different facets of the waves. (c) shows the broad off-specular reflection from the land surface of the North Pole and (d) shows the T120 VIMS color composite (R:5µm, G: 2µm, B:1.3µm)

Data and Observations: We used VIMS spectral cubes obtained at high phase angles (35^0-84^0) (CM_1844022476_1.cub, CM_1844023503_1.cub) during the T120 flyby along with RADAR data to correlate the surface features. Figure 2 shows the VIMS T120 observation of clouds, specular reflection from a north polar hydrocarbon lake, and broad off-specular reflection from the solid surface.

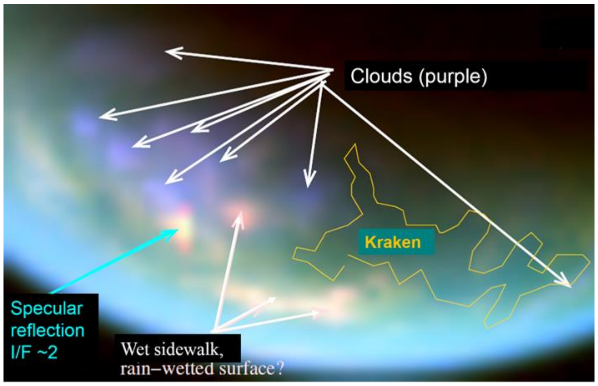

Figure 2 False color composite (R:5µm, G: 2µm, B:2.75µm) of Titan's north polar region showing the specular reflection as very bright orange patches, the rainfall-wetted surfaces (wet-sidewalk effect) as less brighter orange patches and clouds in purplish-blue tones. The extent of Kraken Mare (the north polar largest hydrocarbon sea) is also marked for reference.

Results: Figure 3a indicates the spatial extents of the north polar seas in black and lakes in maroon on a VIMS color composite (R:5, G:2, B: 2.7 µm) overlain on a *Cassini* RADAR map. The extended bright orange patch on the lower left portion of the image is the proposed wetted surface. Figure 3b shows a cloud color composite (R:2µm, G: 2.7µm, B:2.6µm) which shows haze in reddish hue, clouds as bluish-white and surface as green. The arrows mark the putative rainwetted surfaces which appear greenish in the cloud color composite indicating that the feature is near the surface.

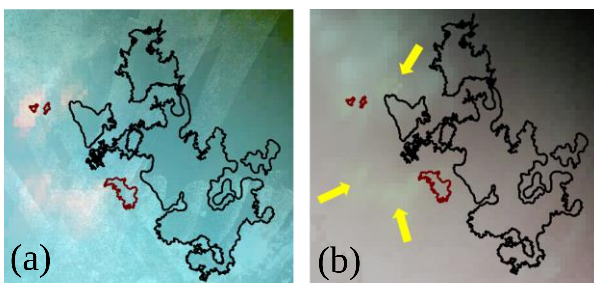

Figure 3 VIMS false color composites of the North Pole with the seas marked in black and lakes in maroon.

We extracted the spectra corresponding to specular, rain-wetted surface, lakes and dry land regions to compare and contrast their reflectances as shown in Figure 4a. The red spectrum is brighter than the land and sea at 5 µm similar to previously observed specular reflections. We also compared the spectra of the rain-wetted region in T120 to the same region in previous flyby (T104) in order to obtain the change in surface characteristics (Figure 4b).

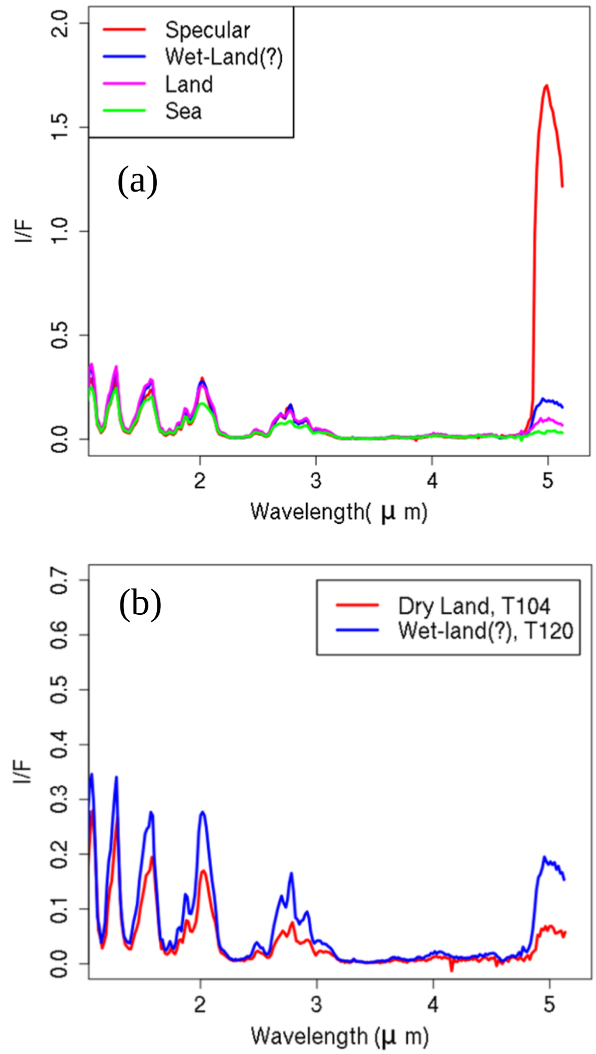

Figure 4 (a) Spectra corresponding to the specular, rain-wetted or wet-land surface, land and sea. (b) Spectra of the region exhibiting wet-sidewalk effect in T120 as compared to T104. In order to account for the geometry both the observations are high phase. T104 phase is 103˚ while T120 is 84°.

References: [1] Stephane et al. (2010) *Geophysical Research Letters, 37,* L07104 [2] Barnes et al. (2014) *Planetary Science, 3:3* [3] Clark et al. (2010) JGR., 115, E10005