TEMPORAL SURVEY OF RAIN EVENTS AT TITAN'S NORTH POLE AS REVEALED BY THE "WET-SIDEWALK" EFFECT Rajani D. Dhingra[1], Jason W. Barnes[1], Robert H. Brown[2], B. J. Buratti[3], Christophe Sotin[3], P. D. Nicholson[4], Kevin H. Baines[5], Roger N. Clark[6], Jason M. Soderblom[7], Ralf Jaumann[8], Sebastien Rodriguez[9], Stéphane Le Moúelic[10] , [1]*Department of Physics, University of Idaho 875 Perimeter Drive, Moscow, ID 83843, USA,* [2]*Dept. of Planetary Sciences, University of Arizona, AZ, USA,* [3]*Jet Propulsion Laboratory, Caltech, CA, USA,* [4]*Cornell University, Astronomy Dept., NY, USA,* [5]*Space Science & Engineering Center, University of Wisconsin-Madison, WI, USA,* [6]*U.S.G.S., Denver, USA,* [7]*Dept. of Earth, Atmospheric and Planetary Sciences, MIT, MA, USA,* [8]*Deutsches Zentrum fr Luft- und Raumfahrt, 12489, Germany,* [9]*Institut de Physique du Globe de Paris (IPGP), CNRS-UMR 7154, Universit Paris-Diderot, USPC, Paris, France,* [10]*Laboratoire de Planetologie et Geodynamique, CNRS UMR6112, Universite de Nantes, France*

Introduction: Titan is the only place besides the Earth known to host a hydrological cycle. An axis tilt of 26°, similar to Earth, also causes seasons on this planet-like moon. As summer approached Titan's northern hemisphere (2009) the expected increase in storm and rain activity were not detected, whereas big cloud systems and storms [1, 2, 3] were observed on Titan's south pole during the southern summers. The contrast of storm and cloud activity in the two hemispheres over the summer, not forecasted by Titan's Global Circulation Models (GCMs), indicates a delay in the northern summer and is not consistent with current Titan weather models.

We recently reported a bright feature [4, 5] in the *Cassini* VIMS (Visual and Infrared Mapping Spectrometer)[6] T120 observation (June 07, 2017) of Titan. The feature is a broad-specular reflection, similar to a wetted side walk after a rainfall event [7]. This reflection off of Titan's surface marks the detection of a potential rainfall event on the north pole (using the wet-sidewalk effect) and heralds the arrival of northern summer on Titan.

In this work, we conduct a temporal and spatial survey of the subsequent *Cassini* flybys (T121–T126) just before the end of the *Cassini* mission to systematically search for other potential rainfall events using the wet-sidewalk effect on the north pole of Titan. With the same purpose, we also look at previous flybys to identify any missed rainfall events.

Objectives: The primary objective of this work is to study the temporal and spatial evolution of rain-wetted surface on the north pole of Titan to aid our understanding of seasonality of the methane cycle and its evolution through time. These observations would also enable us to explore the reasons GCM predictions of northern summers differ from the observed rainfall/storm activity.

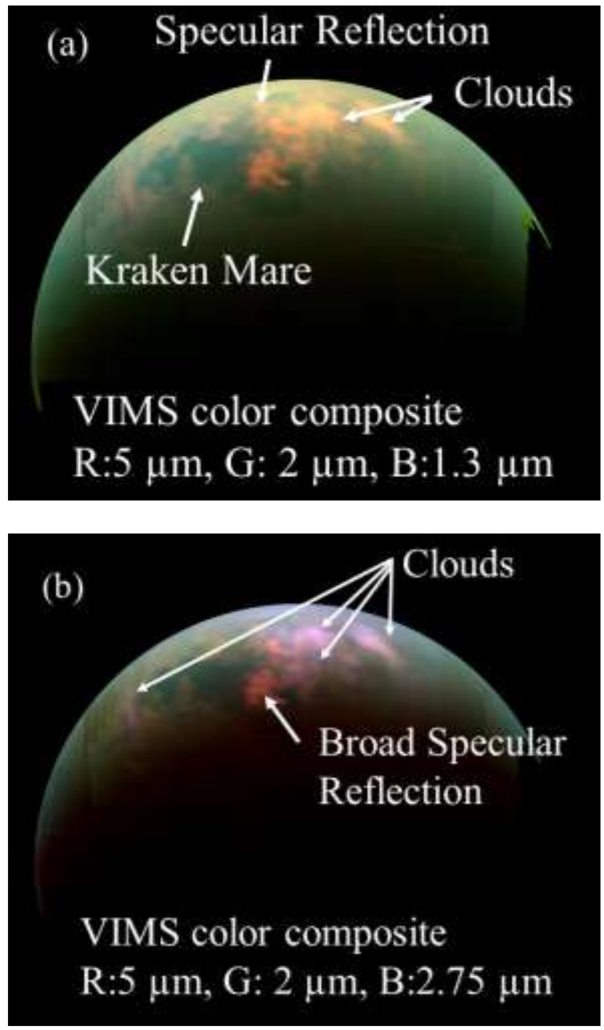

Figure 1 Titan's north pole showing wet sidewalk glints and clouds in different color composites. (a) shows the north pole of Titan (T121 flyby (July 25, 2016)) in "VIMS color composite". Clouds and broad specular reflection, both look reddish in this color composite. (b) T121 flyby in VIMS "wet-sidewalk color composite" to enable separation of the clouds from the broad specular reflections from (near) surface. In this

composite clouds look purplish while the broad specular reflection (wet-sidewalk region) has a reddish hue.

Data and Methods: We go through the *Cassini* VIMS dataset (T100 onward) to detect any wet-sidewalk glints. We generate orthographic images of the *Cassini* flybys to observe any anomalously bright regions in the VIMS color composite (R:5µm, G:2µm, B: 1.3 µm) (Fig 1(a)). As a first identifier, the wet-sidewalk reflections look bright in this color scheme. Another color composite using a different wavelength combination (R:5µm, G: 2µm, B:2.75µm) differentiates the clouds and surface/near-surface. We call this color scheme the wet-sidewalk color composite (R:5µm, G: 2µm, B:2.75µm) (Fig 1(b)). Clouds take a purplish hue in this color composite (Fig 1(b)) while other features on surface or near surface take a reddish hue. We then use the RADAR and ISS maps of the north pole to locate the region's location-solid or liquid. Spectral comparisons and simulations [7, 8] to understand the uniqueness for the bright regions are underway.

Flyby	**Date**	**Obs. Geom**		
		P	**I**	**E**
T106	Oct 24, 2014	115º	68º	56º
T120	Jun 07, 2016	116º	52º	65º
T121	July 25, 2016	113º	68º	46º
T123	Sept 27, 2016	112º	53º	61º

Table 1: VIMS flyby details of the wet-sidewalk reflections over north polar region of Titan. P, I and E indicate the Phase, Incidence and Emission angles of the observation. These play an important role due to scattering caused by the atmosphere.

Figure 2 Wet-sidewalk action on Earth. At suitable observation geometries, the wetted road looks bright reflecting the solar flux at the observer similar to our observations over Titan's north pole. We can also observe the specular reflection coming off of the rear windshield of the car.

Results: We have so far detected broad specular reflections from at least three other observations of Titan's north pole (apart from the first detection made in the T120 flyby). The flybys containing the broad specular reflections are tabulated in Table 1. This temporal variation study of broad specular reflections acts as a weather monitoring methodology for Titan and will help in understanding seasons and the long term climate of Titan.

References: [1] Turtle et al., (2011) GRL, *38*, 1151–1154. [2] Rodriguez et al., (2009). [3] Rodriguez et al., (2011) [4] Dhingra et al., (2016), LPSC, Abstract #1519 [5] Dhingra et al., (2017), *Submitted.* [6] Brown et al., (2004) SSR, 115 [7] Barnes., et al. (2013) Icarus [8] Soderblom et al., (2012) Icarus