Evolution of surface changes and weather on Titan in the wake of the Fall 2010 equatorial storm

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Post-equinox changes in atmospheric circulation brought clouds and extensive methane rain to Titan's low latitudes, and large low-latitude clouds observed in Sept.-Oct. 2010 (Fig. 1) were quickly followed by changes (Fig. 2) attributed to extensive methane rainfall darkening the surface [1, 2]. Cassini Imaging Science Subsystem (ISS) observations in Oct. 2010 (Fig. 2) revealed differences in surface brightness along the southern boundary of Belet, one of Titan's largest dune fields. An area 510,000 ± 20,000 km^2, extending ~2000 km east-west and >130 km across, darkened >10%, adjacent areas remained unchanged.

It is likely that much of the darkening was caused by surface wetting [2], although runoff and ponding may have occurred in some areas, explaining the variation in the rates at which the surface has reverted to its original brightness as different areas drain (by overland flow or infiltration) or dry at different rates. A few small areas that appear to have brightened relative to their original appearance could be surfaces (potentially water ice [3]) cleaned by runoff or persistent low-altitude clouds or fog.

The frequency of and amount of precipitation from large storms at low latitudes during the equinoctial transition have important implications for Titan's methane cycle, atmospheric circulation, and rates of geologic modification. Although there is evidence that liquids have flowed on Titan's surface at the equator in the past -- fluvial channels are observed at all latitudes [4] -- to date liquids have only been observed on the surface at polar latitudes [5]. The Huygens Probe also detected methane moisture in the shallow subsurface [6–8] of the cobble-strewn flood plain at ~10°S where it landed [9, 10]. Vast equatorial areas of long-lived longitudinal dunes [11] indicate that low latitudes are predominantly arid [12]; models predict low-latitude storms around equinox provide insufficient precipitation to accumulate there over the course of a year [13].

A series of images over the several months that have elapsed since the storm has revealed that in most of this area the changes have been short-lived: only a few patches persisted through April 2011 (Fig. 2). In an unsaturated permeable medium, vertical infiltration rates will be high (>20 mm/week [14]), so persistence of surface liquids over a timescale of several months strongly suggests either a shallow impermeable layer or that the local methane table lies close to the surface. Evaporation rates of >1 mm/week are predicted in equatorial regions [13] (rates of 20 mm/week have been documented at Titan’s poles [15]), thus areas where darkening has persisted must be saturated ground at the methane table or have had ponded liquid of 2.5-50 cm depth.

We have continued to monitor Titan frequently (at least a few times per month), but to date no significant cloud activity has been observed since Fall 2010. This lack of clouds may indicate that the outbreak removed enough CH_4 from the atmosphere and the lapse rate stabilized sufficiently that activity will not resume until the onset of convection at mid-northern latitudes later in the spring.

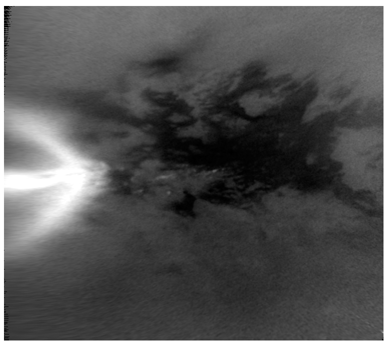

Figure 1: Extensive near-equatorial cloud, 27 Sept. 2010. Bright features are tropospheric methane clouds; grey and darker shades are surface features.

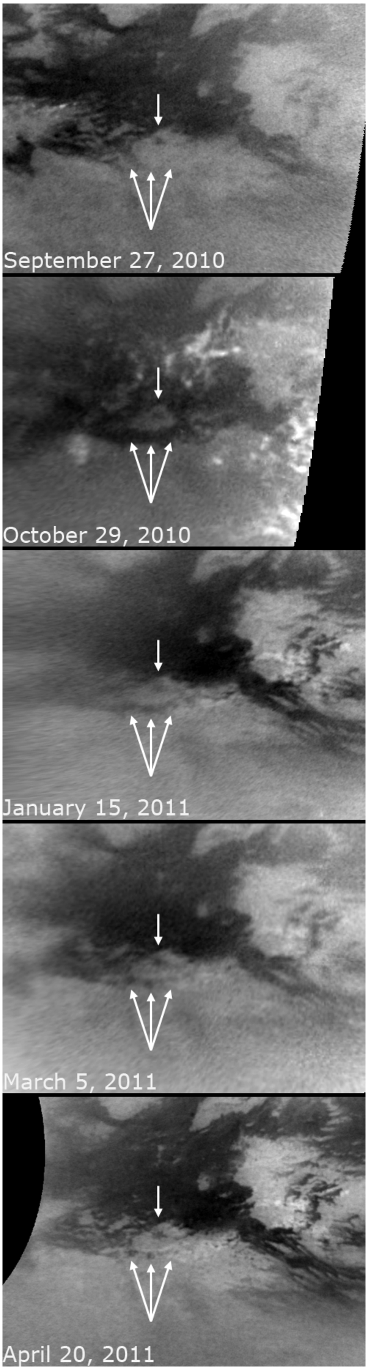

Figure 2: Sequence of ISS observations. Single arrow indicates isolated unchanged area between Belet and the darkened swath. Triple arrow highlights darkened swath on 29 Oct. 2010 and evolution thereof. Bright features on 27 Sept. and 29 Oct. are tropospheric methane clouds; grey and darker shades are surface features. North is up.

Acknowledgements

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