CASSINI IMAGING SCIENCE SUBSYSTEM OBSERVATIONS OF TITAN'S HIGH-LATITUDE LAKES.

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Introduction: Cassini's Imaging Science Subsystem (ISS) has been observing Titan for three years, beginning during final approach to the Saturnian system in Spring 2004 [1] and continuing through the 30 targeted Titan encounters that Cassini has performed through 12 May 2007. Titan's atmosphere obscures its surface quite effectively at visible wavelengths, so the ISS narrow- and wide-angle cameras include narrow bandpass filters at 938 nm and IR polarizer filters [2] to take advantage of a window in methane's absorption spectrum in the near-IR where the optical depth of Titan's complex organic atmospheric haze is lower and the fact that the haze is highly polarized near phase angle 90º [3]. However, even with these filters, scattering by haze particles limits the best resolution that can be achieved to ~1 km [2]. Despite the challenges presented by Titan's atmosphere, to date Cassini has imaged almost all of Titan's illuminated surface at resolutions of tens of kilometers and a substantial fraction of the surface at significantly better resolution, down to the limit imposed by atmospheric scattering. These observations have been combined to produce an albedo map of the surface (Fig. 1; see also Perry et al. [4] for even more recent observations).

Observations and Interpretations: The brightness variations revealed by ISS are due to the presence of surface materials with different albedos rather than topographic shading. Even high-phase-angle images are likely to reveal only albedo markings: (1) an icy satellite of this size is not expected to have topographic relief high enough that shadows would be detectable at kilometer scales [5]; and (2) atmospheric scattering severely reduces the contrast between slopes facing towards and away from the Sun. Observations repeated with different illumination angles have not revealed changes consistent with topographic shading.

The compositions of the materials responsible for the observed albedo variations are still not well understood; however, morphologic interpretations of ISS images as well as observations by Cassini's RADAR and Visual and Infrared Mapping Spectrometer (VIMS) and by Huygens' Descent Imaging Spectral Radiometer (DISR), appear to have confirmed hypotheses that darker regions are generally lower elevations where liquid and solid hydrocarbons, which are expected to have precipitated from the atmosphere in substantial quantities over Titan's history [e.g., 6], have accumulated, while brighter regions represent higher-standing exposures of less-contaminated water-ice bedrock or brighter organic material [e.g., 1, 7-11].

The morphologies of the albedo patterns observed on Titan's surface appear to represent a wide variety of geological features (Fig. 1; see also [1, 4]): linear boundaries likely indicate faulting and tectonic control; bright, roughly east-west, streamlined shapes suggest aeolian processes, consistent with RADAR observations of expanses of dunes covering the dark equatorial regions [12]; narrow, curvilinear, dark lines that wind across the surface appear to be fluvial channels; Ontario Lacus, a dark feature near the South Pole that is a few hundred kilometers long with a smooth margin is suggestive of a lake (Fig. 2; [13]); the relatively uncommon circular albedo features have often been confirmed to be impact structures [14], further evidence for a geologically young surface; and other, more complex, patterns still defy easy interpretation. To date we have not observed any evidence of changes in surface albedo patterns.

Lakes and Seas: Although ISS has observed the specular point at numerous locations at low latitudes on Titan's surface, detailed analysis has detected no enhancement, indicating no substantial coverage of the surface by liquid in these areas. However, illumination geometry and atmospheric scattering prevent useful observations of the specular point at high latitudes where there is more compelling evidence for the presence of surface liquids. In addition to Ontario Lacus, ISS has observed numerous smaller, dark surface features around the South Pole (Fig. 2). Furthermore, large convective cloud systems were commonly observed at high southern latitudes through 2004 [1, 15-16], evoking the interpretation of these features as lakes filled by recent methane rain [13]. The subsequent identification of lakes at high northern latitudes by Cassini RADAR [17], further supports this hypothesis. More recent observations by Cassini ISS of northern latitudes as the approaching equinox brings improved illumination have revealed an extensive low-albedo surface feature with a complex boundary. The structure is more than 1000 kilometers long and at its northernmost extent coincides with a large liquid-filled region identified in an overlapping RADAR SAR swath. If the entire dark region revealed in the ISS observation is currently filled with liquid, it would represent a sea with an area of 340,000 km^2. Thus, the liquid reservoirs required to replenish the hydrocardbons in Titan's atmosphere currently appear to exist in the form of surface lakes and seas at high latitudes.

Upcoming observations: Cassini has completed 30 of the 44 targeted Titan encounters planned during its nominal mission (4 more are scheduled to occur from May through July 2007) and much still remains to be seen, especially as Titan's high northern latitudes emerge from darkness as equinox approaches in August 2009. Further observations by Cassini's suite of instruments and coanalysis thereof will help to further improve our understanding of Titan's surface and the processes at work thereupon.

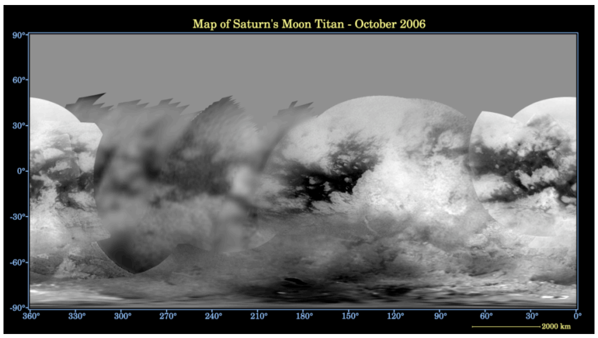

Figure 1: Albedo map of Titan compiled from ISS 938-nm observations (Apr. 2004 through Oct. 2006; http://photojournal.jpl.nasa.gov/catalog/PIA08346). Resolution varies according to available viewing opportunities. It is currently late winter in the northern hemisphere, so high northern latitudes are still poorly illuminated. For improved views of the trailing hemisphere and high northern latitudes acquired more recently see Perry et al. [4].

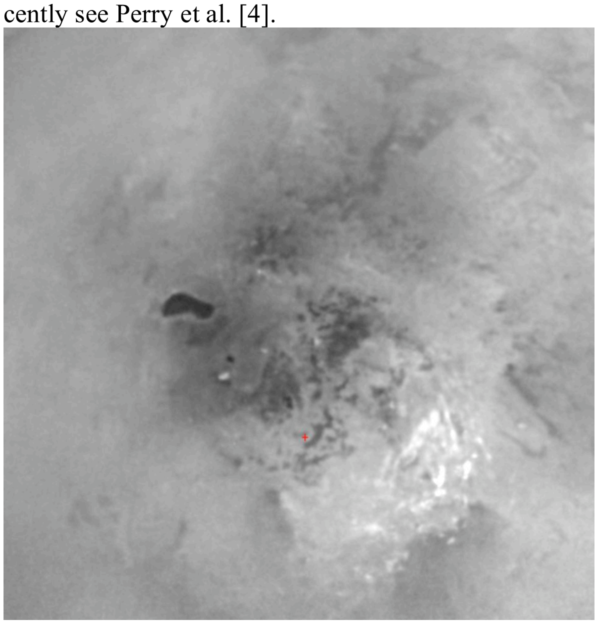

Figure 2: ISS image of Titan's South Pole (marked by the red cross just below center). Ontario Lacus is the relatively large, dark feature to the left of center. Smaller dark features in this region may also be, or have been, liquid-filled lakes similar to those seen at high northern latitudes [17]. The very bright features to the right of the South Pole are tropospheric clouds (cf. a movie of this region illustrating cloud motions at: http://photojournal.jpl.nasa.gov/catalog/PIA06241.)

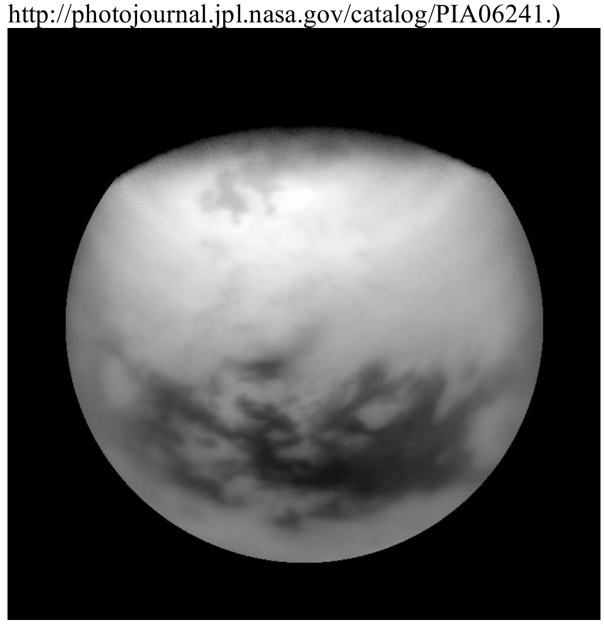

Figure 3: ISS image of Titan's trailing hemisphere at high northern latitudes. The complex dark feature just below the terminator at the top of the disk appears to be the full extent of one of the northern lakes identified by Cassini's RADAR (cf. ISS and RADAR observations combined to illustrate the overlapping coverage: http://photojournal.jpl.nasa.gov/catalog/PIA08365). In contrast, the dark expanses seen toward the bottom of the disk are the equatorial regions of Senkyo (to the west) and Belet (center and east), which have been shown to consist of dark longitudinal dunes [12].

References: [1] Porco, C.C. et al. (2005) *Nature 434*, 159-168. [2] Porco, C.C. et al. (2004) *Space Sci. Rev. 115*, 363-497. [3] Griffith, C.A. et al. (1991) *Icarus 93*, 362-378. [4] Perry, J. (2007) et al., this volume. [5] Perron, J.T. and de Pater, I. (2004) *GRL 31*, L17S04. [6] Lorenz, R.D. and Lunine, J.I. (2005) *PSS 53*, 557-576. [7] Elachi, C. et al. (2005) *Science 308*, 970-974. [8] Elachi, C. et al. (2006) *Nature 441*, 709-713. [9] Soderblom, L.A. et al. (2006) *B.A.A.S. 38*, #52.08. [10] Barnes, J.W. et al. (2007) *Icarus 186*, 242-258. [11] Tomasko, M.G. et al. (2005) *Nature 438*, 765-778. [12] Lorenz, R.D. et al. (2006) *Science 312*, 724-727. [13] McEwen, A.S. et al. (2005) *B.A.A.S. 37*, #53.04. [14] Lorenz, R.D. et al. (2007) *GRL 34,* doi:10.1029/2006GL028971. [15] Schaller E.L. et al. (2006) *Icarus 182*, 224-229. [16] Schaller E.L. et al. (2006) *Icarus 184*, 517-523. [17] Stofan, E.R. et al. (2007) *Nature 445*, 61-64.