Temperate Lakes Discovered on Titan

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We have discovered two temperate lakes on Titan using *Cassini*'s Visual and Infrared Mapping Spectrometer (VIMS). Three key features help to identify these surface feature as lakes: morphology, albedo, and specular reflection. The presence of lakes at the mid-latitudes mean liquid can accumulate and remain stable outside of the poles. Cloud activity and rain at the mid-latitudes also supports lake formation. Stable liquids outside of Titan's poles constrain Titan's hydrologic cycle as well. By first identifying the lake morphology of an area, a simple atmospheric correction produces an approximate surface albedo. Next, cylindrical projection maps of the brightness of the sky as seen from any points on the surface can compared to identify specular reflections. Our techniques can then be applied to other areas, such as Arrakis Planitia, to test for liquid.

Introduction

Lakes on Titan are concentrated at the poles, along with dry lakes, while all the observed deserts and dunes are near the equator. Boundary conditions on global circulation require volatiles build up at the poles. Rain and clouds have been seen and have concentrated around the 40° latitude marks [1, 2], but no liquids had been previously identified. Here, we show evidence from Cassini VIMS of two partially filled lakes near 40°S. This discovery is important because it shows that liquids can accumulate and be stable outside the polar regions and allows us to place constraints on Titan's hydrological cycle.

Observations

Polaznik Macula (Figure 1) was viewed by VIMS on the T66 flyby (rev 125) and is shown in contrast to its surroundings. Distinctions in the dark area are revealed upon further inspection. At first, the lower right portion, located at 81.7°E, 41.4°S, of the macula stood out to us as darker than the rest. The initial assumption is that this area is a lake currently filled with liquid. A second area just past the the upper right boundary of the darkened area also outlined in blue shows a similar contrast to the lower right area and is also thought to be a filled lake. Two other areas show slightly brighter surface reflectivities and may be candidates for lakes, though currently unconfirmed. The rest of Polaznik Macula can then be explained as ancient or recent dry lake bed.

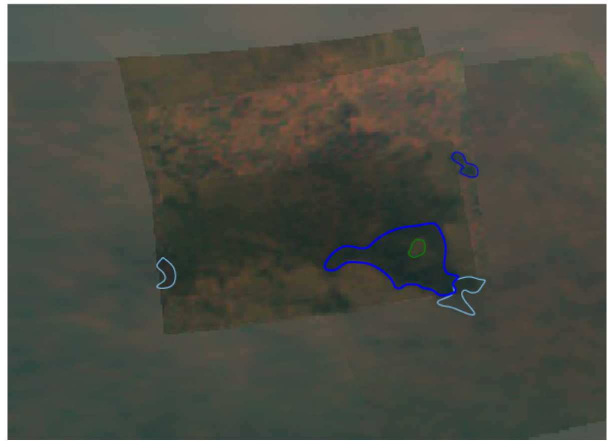

Figure 1: The encircled dark blue areas represent positively identified lake regions in the T66 flyby. The light blue areas represent lake candidates still being disambiguated. The green circle marks a non-lake surface feature enclosed by a lake.

Atmospheric Correction

We define I/F to be the total measured upward intensity divided by the solar flux. We make the major assumption that contribution from photons scattered by the atmosphere multiple times is negligible. The contributions to I/F we consider are:

1. Radiation reflected from the surface, wholly unscattered on its trip through the atmosphere or back up.
2. Radiation scattered upward by the atmosphere before reaching the surface.
3. Radiation scattered by the atmosphere downward into the surface, then reflected upward by the surface and unscattered on its passage back out of the atmosphere.

We have implemented a partial, analytical, single-scattering atmospheric correction in order to derive surface albedo from measured I/F.

Interpretation

We have three lines of evidence to support the nomenclature of "lake" for these surface features: morphology,

Figure 2: The reflection of the sky can be seen here on the surface of Crater Lake, Oregon, USA.

surface albedo, and specular reflection. The morphology of a surface feature can be judged to be a lake or non-lake by comparing it to other known and verified lakes on Titan, such as Ontario Lacus. The boundary of the features outlined in dark blue in Figure 1 are consistent with a shoreline for VIMS. The approximate surface albedo can be gleaned from an atmospherically corrected map of the surface feature with a single-scattering assumption and then compared to known bodies of liquid. The model, as described in the previous section, reports surface albedos within the dark blue areas of Figure 1 as a match after explicitly comparing the measured albedo with that of Kraken and Ligeia Mare. The rest of the dark area in Polaznik Macula resulted as similar to dune albedo. We have evaluated other temperate dark surface features exhibiting lake morphology, but none have passed this albedo test. A final test to confirm lakes is to observe a specular reflection. The specular reflections can be seen by producing a cylindrical projection of the brightness of Titan's sky as viewed from a point on the surface. We are looking for specular reflections from illumination of the lake by the sky and not by illumination from the Sun (Figure 2). This final test is a work in progress.

Implication

Currently, all the known lakes on Titan are concentrated at the poles. Lakes have been suggested in the tropic zone by Griffith et al. [3]. Our interpretations of Titan's hydrologic cycle are impacted now with the inclusion of non-transient temperate lakes. Clouds have been recorded accumulating in the mid-latitudes and areas have been darkened by rainfall but later brightened after evaporation [4]. Stable temperate lakes would affect total rain fall, liquid accumulation, evaporation rates, and infiltration. Polaznik Macula is a great candidate for lake filling, evaporation rates, and stability.

The emergence of liquid-related surface features outside of the polar areas suggests the mid latitudes would be good targets for several instruments on Cassini. Dark, morphologically interesting areas will be of particular interest as the Solstice tour continues. Cross referencing of areas, if coverage exists, between VIMS and ISS and RADAR will disambiguate the nature of these surface features.

Acknowledgments

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