Sand Sources and Transport Mechanics on Titan

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Introduction

We are using *Cassini*'s Visual and Infrared Mapping Spectrometer (VIMS) to study Titan's sand. Specifically, we are constraining the sand's composition, how it is formed, and how it moves. The precise composition of the sand is still unknown. Water ice has been ruled out, leaving atmospherically-derived hydrocarbons as the best fit. The precise superposition of phases the compound is remains a mystery. Many dry lake beds have been found near and around the poles of Titan via *Cassini*'s RADAR [1]. Capitalizing on tidally driven global winds that are present on Titan [2], we present a new possible mechanism for creation and distribution of the sand.

Sand Sources

The sand itself is thought to be created out of hydrocarbons [3, 4]. Our proposed mechanism posits that sand could be formed in lake beds similar to the sand-formation process at White Sands, NM. As the methane/ethane [5] lakes dry out seasonally [6, 7], the crust of the leftover lakes begin to erode into smaller and smaller particle sizes until saltation is possible, giving birth to sand. As pointed out by Lorenz et al. [8], the winds are strong enough to carry sand-sized particles across the globe. The low gravity of Titan and density of the air help in bringing the required threshold of wind carrier speed down. Dry lake beds could quite possibly not be the only source of sand on Titan, given how much sand there is in the equatorial belt, but they could certainly contribute. The channels and fans present on Titan also put the erosion of lithified hydrocarbons into play as another sand source.

Sources of sand can be evaluated by matching the pure sand spectrum from Barnes et al. [4] to candidate terrains. We consider an area to be a sand source candidate if the spectral type for a given terrain matches the spectral unit for a known sandy area. We are evaluating several locations at present using publicly available data from the NASA Planetary Data System (PDS).

Substrates

The sand seas reside in the equatorial region of Titan. The longitudinal nature of the large expanses of dunes are evidence of the winds that shape Titan's middle. Tidally driven and seasonal winds are thought to be a mechanism by which the sand is brought from the polar regions to the equatorial.

The existence of different compositional substrates within this equatorial region raises several questions. First, why do the sand seas only reside at the equator and why don't they take up the whole equatorial region? Second, could the dunes be covering up the same bright terrain that makes up Xanadu, for instance? Are the darker albedo regions sand sinks, where the sand gets semi-permanently sequestered and forms a new type of hydrocarbon substrate? Also, within the sand dunes, there are sections of icy-substrates that lead in to darker dunes, acting as an intermediary from bright spectral types to dark. The global map of Titan using the VIMS-Visible data shows distinct boundaries between albedos.

Techniques

The map we present (Figure 1) uses three methane windows, 0.754μm, 0.827μm, and 0.937μm, from the VIMS-Vis channels to create a global scale RGB map using blue, green, and red to the respective wavelengths. Using part of an algorithm developed by Perry et al. [9] and employed in Stephan et al. [10], we create a map of pure haze using 9 channels from VIMS-Vis and divide this by our first optical wavelength map of Titan to remove the haze. The resulting map reveals just as much major surface contrast as IR maps as well as provides distinct boundaries between spectral types. Furthermore, the vis maps allow easy identification of water-ice dune substrates due to the greater spectral contrast between dunes and water ice at visible wavelengths.

With the aid of this map, we can use the contrast to match the dark areas of the sand seas in the equatorial belt to other place on Titan. The light blue spectral types may be areas that are producing sand that is then moved by the winds. Such locations may be southeast of Shangri-La, around Tsegihi, and south of Adiri. Other dark spots scattered over Titan may be active places of sand formation. Some active sites may include those north of Fensal, north of Belet, north of Xanadu, and also around Tsegihi.

Conclusion

Is the sand we see all that exists, or is that sand part of an ongoing, active near-surface hydrocarbon sand cycle

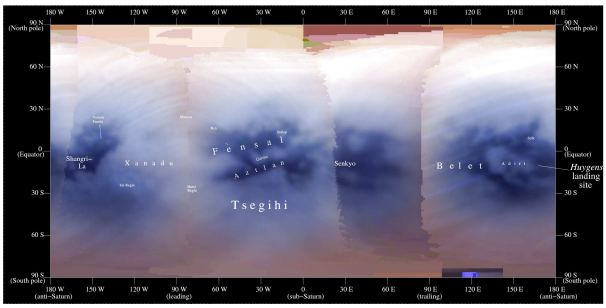

Figure 1: This is a global map of Titan done using an algorithm to "divide" out the atmospheric haze component. In doing so, the surface features and spectra of Titan become more pronounced. Removing some of the haze also brings out the striping effects that are inherent to the VIMS-V system. The differing colors represent different spectral types, allowing for identification of the icy substrates.

wherein sand is continuously being produced by erosion or wind? Then, from the active dunes in the equatorial region of Titan, does the sand become isolated and sink in the giant belt of the sand seas, get covered by blankets of ejecta, or get carried away by fluvial means? The winds are certainly strong enough to allow sand sized particles to circumvent Titan. Further VIMS coverage of the polar regions will aid in determining dry lake locations and spectral properties as well as provide most substrate comparison. This work is funded by a grant to JWB by the NASA Outer Planets Research program.

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