EPSC Abstracts
Vol. 9, EPSC2014-651, 2014
European Planetary Science Congress 2014
© Author(s) 2014

# Dunes on Titan from the Cassini Mission

J. Radebaugh, Department of Geological Sciences, Brigham Young University, Provo, UT 84602, USA.
(janirad@byu.edu / Fax: +1 801 422 0267 and the Cassini RADAR Team

## Abstract

Among the many varied landscapes of Titan revealed by the Cassini spacecraft are tens of thousands of sand dunes. These features encompass the equator in vast sand seas and are some of the geologically youngest landforms, perhaps forming and moving currently, under Titan's active winds. Dunes provide information about wind direction and magnitude and reveal climate conditions now and in the past.

## 1. Introduction

Dunes on Titan, a dominant landform comprising at least 15% of the surface, represent the end product of many physical processes acting in alien conditions. Winds in a nitrogen-rich atmosphere with Earth-like pressure transport sand that is likely to have been derived from complex organics produced in the atmosphere. These sands then accumulate into large, planet-encircling sand seas concentrated near the equator. This is a summary of research on dunes on Titan after the *Cassini* Prime and Equinox Missions (2004 – 2010) and now during the Solstice Mission (to end in 2017). Cassini dune studies currently involve data analysis and modeling of conditions on Titan and utilize comparisons with observations and models of linear dune formation and evolution on Earth.

## 2. Dune Form and Composition

Dunes on Titan are predominantly linear and similar in size and form to the large linear dunes of the Namib, Arabian and Saharan sand seas. They likely formed from wide bimodal winds and appear to undergo average sand transport to the east, as indicated by interactions with topographic obstacles. While most (>90%) of the dunes visible to *Cassini* SAR are considered linear in form, there are some other dune morphologies near the resolution limit that reveal a changing wind regime. Features such as discontinuous crestlines, elongate horns, diffraction-type patterns reveal changing wind conditions, at least locally. Dunes appear as some of the darkest materials to ISS (at 938 nm) and have a low albedo and red slope as seen by VIMS, thus comprising the VIMS dark brown spectral unit. This means the sands are comprised of organics derived from upper atmospheric processes. Once the organics settle to the surface, they may form sedimentary layers that become hardened, through sintering or diagenesis via an introduced, organic cement, and then eroded by methane rainfall and channel formation into particulate sands.

## 3. Sand Seas on Titan

Dunes on Titan are dominant features, covering an estimated 16% or 15 million km$^2$ (or 10-17 million km$^2$ in earlier studies). By comparison, dunes cover up to 4% of Earth's surface, or up to 30% of the area classified as arid, 0.06% of the surface of Mars, and 0.004% of the surface of Venus. Dunes on Titan are found between 30° N and 30° S latitude and nearly encircle the globe at the equator. A collection of named sand seas rings the equator of Titan. They are fairly regularly spaced and are separated from each other by bedrock, as discerned by the SAR-bright, ISS-bright, and VIMS-blue (characteristic of water ice) characters of bedrock materials. Dune areas on Titan are found at generally moderate elevations; thus, their locations must be a function not only of topography, but of winds and sediment availability.

## 4. Dunes and Climate

The question of longevity of individual dune forms, dune fields, and sand seas is intricately linked with the persistence of climate, locally and globally. Dune morphologies are strongly tied to wind properties, so dunes can reveal past and present wind and climate conditions in dune regions. Because linear/longitudinal dunes have several kilometer sizes, they require thousands of years to respond to wind regime changes. Detailed analyses of dune parameters such as length, height, width and spacing reveal correlations and provide comparisons between linear dunes in the solar system. The singular form of Titan's dunes across the satellite, and regular variations in width and spacing across sand seas, indicates they may be highly mature, and may reside in a condition of stability that permitted their growth and evolution over long time scales. The dunes are among the youngest surface features, as even river channels do not cut through them. However, reorganization time scales of large linear dunes on Titan are likely tens of thousands of years. Thus, Titan's dune forms may be long-lived and yet be actively undergoing sand transport.

## 5. Conclusions

Dunes are a dominant landform on Titan, and are the result of a long sequence of processes in the atmosphere and on the surface, including atmospheric chemistry, formation of sedimentary layers, erosion by rainfall, fluvial transport, and finally, wind action. Sand seas encircle Titan's equator, and morphologies indicate that global, eastward sand transport is halted only by large landmasses or diverted on a local scale by topographic obstacles. The dune forms are dominantly linear, and indicate bimodal, likely seasonal, winds that average over time and strength at Titan's surface near the equator as westerlies. Sands are likely composed of complex organics derived from atmospheric photochemistry, perhaps deposited into sedimentary layers, and then eroded by methane rainfall into saltatable particles. Dunes highlight some of the most recent, and perhaps even current, processes on Titan's surface. However, the dunes appear to be from a single population and highly mature, so erosion, transportation, and accumulation processes could operate over long time scales. Ongoing studies of dunes and sand seas on Earth, their dynamics, and the conditions required to form and sustain them will increase our knowledge about large linear dunes on Titan. Conversely, studies of dunes on Titan, which form in the absence of vegetation or equatorial oceans and appear to erase evidence of ongoing precipitation at available resolutions, should also advance our understanding of Earth's dunes. Combined studies will help resolve questions about solar system dune formation, sand transport, wind and climate now and in the past.