EPSC Abstracts
Vol. 13, EPSC-DPS2019-345-3, 2019
EPSC-DPS Joint Meeting 2019

EPSC
EPSC-DPS Joint Meeting 2019
15–20 September 2019 | Geneva, Switzerland

Evidence for Tidal Currents in Titanian Seas from Observations of Persistent Wave Activity

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Summary

Atop Titan's seas; Spectacular speculars; But not gnarly waves

Introduction

Titan is the only natural satellite to hold a substantial atmosphere and liquid bodies on its surface. The *Cassini* probe observed sunglints or specular reflections off of the northern hydrocarbon lakes and seas [1, 2]. These sunglint observations have been exploited to characterize surface roughness on the seas and larger lakes [3]. As a result, Visual and Infrared Mapping Spectrometer (VIMS) observations and specular modeling [2, 4] have revealed millimeter (wave-free) to centimeter (capillary waves) sea surface heights in Punga Mare, Kraken Mare, and Jingpo Lacus [1, 2, 3]. *Cassini* RADAR observations also support this interpretation of still to choppy sea surface conditions on the northern seas and lakes [5, 6]. The literature has suggested that wind-driven gravity waves are the likely source for the observed rough sea surfaces [7]. However, alternative theories have been proposed to explain observed sea surface roughness, such as tidal-sloshing currents [8]. We find observational evidence for tidally induced currents in two narrow straits (fretum) of Kraken Mare, Seldon and Bayta Freta.

Methods and Results

We performed a photometric and spectroscopic analysis on select T104 VIMS cubes with the notable specular reflection seen as a bright white spot in Figure 1. We utilized a "wet sidewalk" RGB color scheme (R: 5 µm, G: 2.7 µm, B: 2 µm) to identify anomalous bright spots in Kraken Mare offset from the specular reflection [9]. The spectra of the selected pixels, highlighted in Figure 1, are brighter than nearby sea pixels in the 5 µm window, which we interpreted as rough sea surfaces. These "wavy" pixels are also offset from the specular reflection and located in preferential areas of the sea where tidal waves might manifest [8, 10]. Bayta Fretum has a notable sunglint of 5-6 pixels indicative of a large field of possible coastal zone waves. Initial model estimates constrain the Bayta wave heights to 1-2 centimeters [11]. In addition, the persistence of the Bayta sunglint observation over many hours leans evidence to the interpretation of a tidal flow compared to a continuous sea or land breeze [11]. Seldon Fretum is ~17 km wide and ~40 km long [8], which corresponds to the separation distance measured between the Seldon 1 and 2 "wavy" pixels. Given the spatial distribution of Seldon 1 and 2, this provides evidence for fluid exchange through Seldon Fretum. The difference in I/F of Seldon 1 and 2 at 5 µm (Figure 1) could suggest an asymmetry in the tidal current or could be an artifact due to differences in the viewing geometry. However, this interpretation is hard to constrain without knowledge of the bathymetry [8, 10]. Overall, this work highlights the role of tidal forces in the fluid exchanges of Titan's hydrocarbon seas and subsequent extraterrestrial oceanographic phenomena, such as tidal currents and coastal waves.

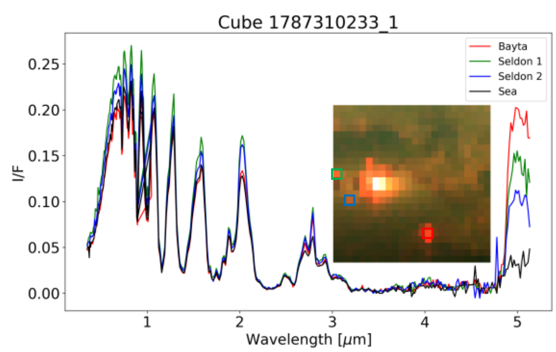

Figure 1: Spectra of 3 separate detections of "wavy" pixels compared to a nearby sea pixel (black). The inset image is a cleaned VIMS cube 1787310233_1 assigned a wet-sidewalk color scheme [9]. Boxes indicate the brightest "wavy" pixels. Seldon 1 and 2 refer to the south and north ends of Seldon Fretum respectively.

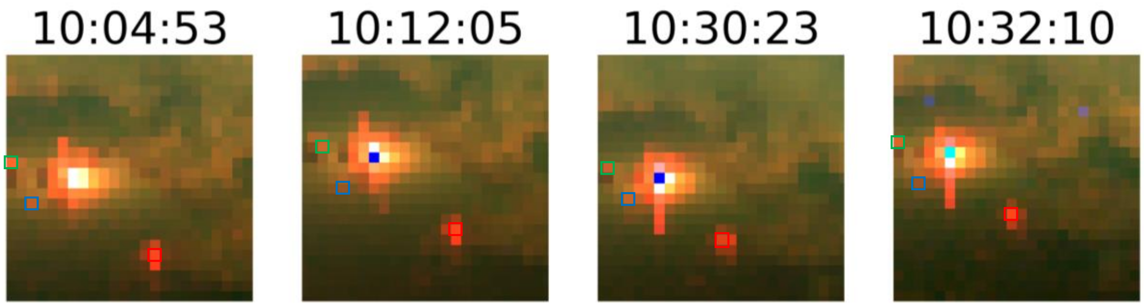

Figure 2: Time series of cleaned T104 VIMS cubes from left to right: 1787310233_1, 1787310294_1, 1787311722_1, and 1787311877_1. The RGB color and "wavy" cube boxes are the same as Figure 1. The image titles are the respective observation mid-times. The resolutions range from 17-21 km/pixel. Blue pixels in the center of the specular reflection are saturated.

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