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10 years of observation of Titan's lakes with the Cassini RADAR Radiometer

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Abstract

Since 2004, the Cassini RADAR Mapper has been exploring at a wavelength of 2.2-cm Saturn's moon Titan, the only planetary body besides Earth whose surface presently exhibits significant accumulations of liquids in the forms of lakes and seas. In its passive, or radiometry; mode of operation, the Cassini RADAR Radiometer measures the microwave thermal emission from the surface. Doing so, it provides unique insight into properties such as physical temperature, overall composition and structure (roughness, heterogeneity…). To date, the Cassini Radiometer has mapped almost the whole surface of Titan. In this paper, we review the radiometry data acquired over Titan's lakes searching for new constraints on their composition, bed depth and potential regional and seasonal variations.

1. Introduction

For the last 10 years, the passive radiometer that is incorporated in the Cassini RADAR instrument has been observing the 2.2-cm wavelength thermal microwave emission from Titan. The radiometry global mosaic first published in [1] has been recently updated to include all data accumulated through T95 (October 2013) and its calibration has been refined to an unprecedented accuracy of 1%. Here we report on the data collected over Titan's lakes and in particular: the northern seas Ligeia Mare (LM) and Kraken Mare (KM) and Ontario Lacus (OL) in the South.

2. Constraining lake composition

The lakes and seas are, with the dunes, the most emissive features on Titan's surface (see Fig. 1). Accounting for the physical temperature variations with time and latitude as observed by CIRS/Cassini (Jennings, pers. com) and assuming no evaporative cooling, lakes are found to exhibit an emissivity at normal incidence of 0.98 ±0.01 implying that:

- the lake surfaces are generally smooth at the wavelength scale
- the lakes have a dielectric constant of 1.78±0.25, consistent with liquid hydrocarbons [2].

Low-resolution polarized radiometry observations of Titan, that can be used to infer the surface effective dielectric constant [1], support both of these results.

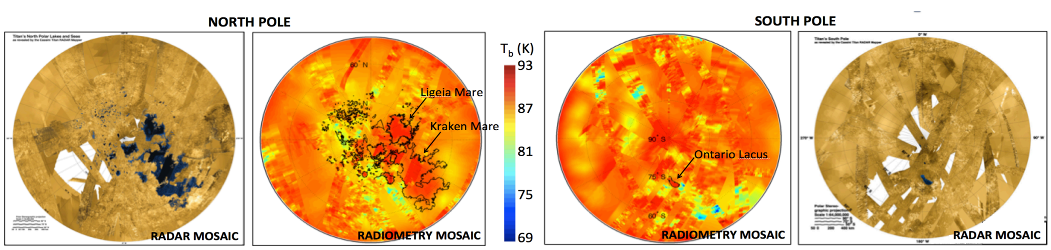

Figure 1: Active (RADAR) and passive (RADIOMETRY) observations of the Cassini Radar Mapper accumulated from 2004 to the present. The radiometry mosaics show the surface brightness temperature at 2.2-cm, all referenced to the same epoch (2005 based on CIRS/Cassini observations of seasonal and latitudinal surface temperature variations) and to normal incidence. The radar polar mosaics are PIA17655; they use false color to distinguish liquid from dry land and have been cosmetically modified to minimize the appearance of seams.

3. Sensing lake bottom

The brightness temperatures measured by the Cassini Radiometer over Titan lakes consist of two contributions: the emission from the lake liquid and the emission from the lake bottom attenuated in the lake liquid. The deeper the lake, the smaller the bottom contribution and the larger the measured signal. This implies that if the electrical properties of the lake liquid and floor are known, the radiometry data can thus be interpretable as lake-bottom topography.

Using a two-layer model [3] and the loss tangent values retrieved for OL and LM we find that the contribution from the bottom to the lake brightness variations reaches its maximum (~0.5 K) if it is a few meters and 200 m deep, respectively. Furthermore, preliminary analysis shows that the brightness temperature profile of LM is very consistent with the bathymetry curve inferred from active altimetry data [4].

4. Looking for regional and seasonal variations

Comparison of radiometry data acquired over Titan's lakes at different latitudes and times provides clues to their regional and seasonal variations. In particular, LM was observed in SAR or altimetry mode at 7 instances over the course of the Cassini mission corresponding to different epochs of the Titan year, which passes through the vernal Equinox in August 2009. KM in the North and OL in the South were both observed 4 times, more closely in time.

Fig. 2a shows the mean brightness temperatures (and their variance) measured over LM, KM and OL since the beginning of the Cassini mission. The rise in brightness temperature observed over LM with time is due to the warming of the northern hemisphere as summer is on its way.

The emissivity is inferred from dividing the measured brightness temperature by the physical temperature which variations with time and latitude have been measured by CIRS/Cassini. Fig. 2b clearly shows that OL is less emissive than the Northern seas. This could be due to:

- a different composition of OL liquid and/or bottom material with a higher dielectric constant and/or
- the evaporative cooling of OL that was observed only around the vernal Equinox i.e. at the end of the southern summer.

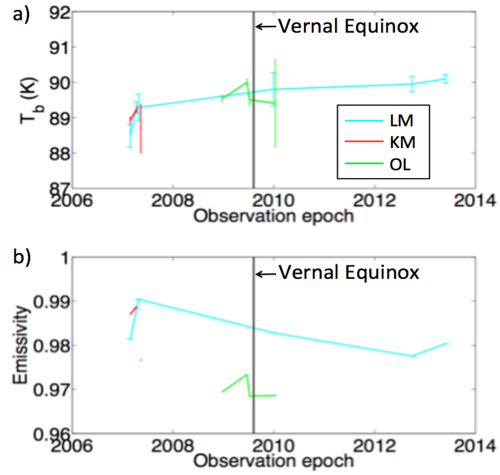

Figure 2: a) Mean brightness temperatures measured over LM, KM and OL since the beginning of the Cassini mission. b) Emissivities obtained by dividing the brightness temperature by the physical temperature as observed by CIRS. Uncertainties on the physical temperature are not included here.

Acknowledgements

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References

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