EPSC Abstracts
Vol. 5, EPSC2010-247, 2010
European Planetary Science Congress 2010

Regional variations among Titan's dunes: Belet versus Fensal dune fields

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Abstract

Titan's equatorial belt is covered by vast longitudinal dunes. Over the last 4.5 years, the Cassini RADAR has revealed some variations among the dune regions. In particular, the Belet and Fensal dune fields differ in terms of radar albedo and thermal emission. We explain these differences by various degrees of exposure of the icy crust of Titan in the interdunes (troughs between the dunes) probably due to variations in the available sediment supply.

1. Introduction

Large expanses of longitudinal dunes cover much of Titan's equatorial regions [1,2]. These dunes hold important clues for Titan's winds, climate and surface materials. Questions remain on their chemical and physical properties and regional variations. As the Cassini mission continues, more of them are unveiled and examined by the microwave RADAR Mapper both in the active and passive modes of operation of the instrument.

In this paper, we examine most of the measurements performed by the Cassini RADAR over the Belet and Fensal dunes from TA (February 2005) through T55 (May 2009) and we combine these different datasets to constrain their chemical and physical properties and provide an explanation for their differences. To better understand the RADAR observations, we have also developed a model that relates the microwave backscatter and emission from linear dunes to their composition and geometry relative to the geometry of observation.

2. Cassini RADAR observations of the Belet and Fensal dune fields

The Cassini RADAR can operate as a Synthetic Aperture Radar, an altimeter or a scatterometer and concurrently acquire passive data.

2.1 Active observations

The Belet and Fensal dune fields were defined using the ISS mosaic (see Fig. 1). They were observed by the Cassini SAR during the T8 and T49 flybys and the T17, T25, T28 and T29 flybys, respectively. On the SAR images Belet's dunes appear more closely spaced and with darker interdunes than Fensal ones. The scatterometry analysis shows that the Fensal region is indeed much more diffusive (i.e. presents a higher backscatter at high incidence angles) than the Belet one, the latter being 2 to 5 dB darker.

Altimetry measurements performed over the Fensal dune field during T30 are consistent with the presence of flat and wide interdunes.

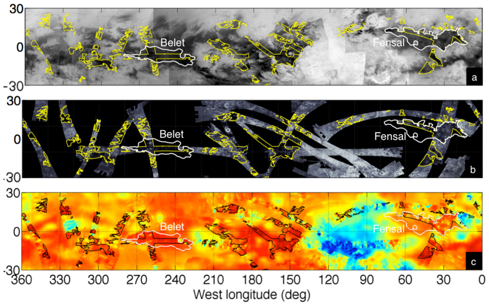

Fig. 1: Low latitude mosaics of the ISS (a), SAR (b) and radiometry (c) observations of Titan. Dune fields mapped from February 2005 to May 2009 are outlined in each map. The Fensal region is at higher latitudes than the Belet one.

2.2 Passive observations

Radiometry observations indicate that the Fensal region is less emissive than Belet (see Fig. 1), probably owing to a higher surface dielectric constant and/or more volume scattering in the subsurface.

3. Electromagnetic modeling of the linear dunes

Following [3], longitudinal dunes are modeled as a composite of rough facets having a Gaussian distribution of tilts. The assumptions are: (1) dunes are longitudinal characterized by two slip-sides of equal slope (2) interdunes are flat areas, (3) the composition of the dunes differs from composition of the interdunes (4) the interdunes are more diffusive than the dunes themselves; the diffuse scatter arises mainly from subsurface volume processes.

As illustrated by Fig. 2, the radar cross-section is very sensitive to the geometry of observation. When the look direction is approaching the direction perpendicular to the dune long axis, the backscattering cross-section rises and reaches a local maximum when the incidence angle equals the angle of repose of the dune flanks. In contrast, the emissivity is controlled primarily by the composition and the degree of subsurface volume scattering in the dunes and interdunes. The smaller or darker are the interdunes the higher is the brightness temperature of the dune fields.

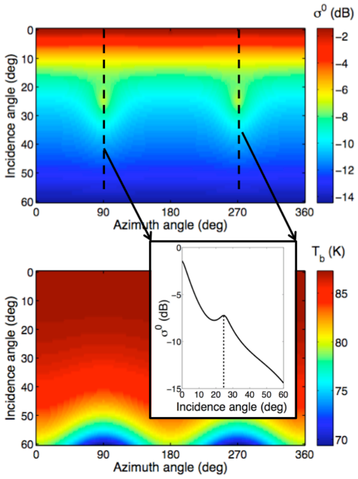

Fig. 2: Normalized radar cross-section and brightness temperature of linear dunes as functions of the radar incidence and look angles (θ and ϕ). The dunes and interdunes are oriented along $\phi = 0°$. The slope of the dunes is 25°. The interdunes are flat. The dunes are as wide as the interdunes. The dielectric constant of the dune (resp. interdune) material is 1.5 (resp. 2.1). The degree of volume scattering in the interdunes is 10%. The polarization is perpendicular to the plane of incidence.

4. Comparison and conclusion

In this paper, we will report on the joint analysis of the active and passive observations of the Belet and Fensal regions and present its comparison with our model. The value of combining radiometry and radar datasets to identify the unique signature of various terrains has been demonstrated by [4]. A 2D Fourier analysis of the SAR images was also carried out to automatically derive the orientation of the dunes needed for the simulations.

Preliminary results suggest that most of the Fensal interdunes are flat sand-free areas where the icy bedrock of Titan is exposed. This is consistent with VIMS observations [5]. The presence of fresh water ice in the ejecta blanket of the Sinlap crater, which is in the vicinity of Fensal, might be a further argument for that. Fensal interdunes could have been slowly grinded flat by sand particles as they move back and forth from one dune to the next. Alternatively, Fensal could exist in a regime where sand is not as abundant, and therefore, interdunes are more exposed, as at Belet. More sand seems to be present at Belet's location may be due to variations in the wind regime and/or the ground humidity.

Acknowledgements

This work was supported by the Cassini/Huygens mission, which is a joint endeavor of NASA, the European Space Agency (ESA), and the Italian Space Agency (ASI) and is managed by JPL/Caltech under a contract with NASA. A. Le Gall is supported by the NASA Postdoctoral Program, administrated by Oak Ridge Associated Universities (ORAU).

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