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**DUNES OF THE DRAGONFLY LANDING SITE SEEN BY THE CASSINI RADAR.** L. E. Bonnefoy<sup>1,2</sup>, A. G. Hayes<sup>1</sup>, A. Lucas<sup>2</sup>, S. Rodriguez<sup>2</sup>, V. Poggiali<sup>1</sup>, D. E. Lalach<sup>1</sup>, R. D. Lorenz<sup>3</sup>, and A. Le Gall<sup>4</sup>, <sup>1</sup>Department of Astronomy, Cornell University, Ithaca, NY, USA, <sup>2</sup>Université de Paris, Institut de physique du globe de Paris, CNRS, Paris, France, <sup>3</sup>Johns Hopkins University Applied Physics Laboratory, Laurel, MD, USA, <sup>4</sup>Laboratoire Atmosphères, Milieux, Observations Spatiales (LATMOS), UVSQ/CNRS/Paris VI UMR 8190, 78280 Guyancourt, France

**Introduction:** The Dragonfly mission, selected through NASA's New Frontiers program, will improve our understanding of Titan's chemistry and geology by sending a rotorcraft to its equatorial dune fields in the mid-2030s (expected launch in 2027) [1, 2]. The landing site is in the Shangri-la dune field near the 80-km-wide Selk crater (6.5°N, 161.5°E), which features traces of erosion by both aeolian and fluvial processes [3, 4]. The region has been imaged by the Cassini RADAR (Ku band, 2.2 cm) in Synthetic Aperture Radar (SAR) mode at incidence angles varying from 5° to 72° and polarizations varying from parallel to perpendicular (to the incidence plane). We take advantage of this dataset to fit backscatter models and extract new constraints on the dielectric constant, root-mean-square (rms) slope, and scattering albedo.

**Methods:** The region of interest around Selk crater, defined by [2], has been imaged by the Cassini RADAR on 9 occasions. From this data, we mapped 6 terrain units: crater rim, crater ejecta, hummocky terrains, plains, dune fields, and dark terrains (in order of decreasing radar brightness). These terrains are largely the same as those identified and mapped by [2] and [4], with the exception of the “dark terrains”, which we define as very radar-dark regions located near dune fields but without clearly apparent dune structures. Within dune fields, the dunes and interdune regions were separated using the method described in [5]. The normalized backscatter cross section ( $\sigma^0$ ) values of each unit within a 0.25° grid were averaged and plotted against the incidence angle in order to assemble backscatter curves.

The dominant mechanism contributing to radar backscatter varies with incidence angle: quasi-specular scattering on facets oriented towards the radar dominates at low ( $\lesssim 30^\circ$ ) angles, whereas at higher angles diffuse scattering from surface roughness and subsurface structures takes over. The quasi-specular component has the dielectric constant and surface rms slope as parameters, and tests three different scattering laws previously applied to Titan: Hagfors, exponential, and Gaussian [e.g., 6, 7]. For the diffuse component, we used either the empirical  $\text{Acos}^n$  model [6, 7] or the simple but physical single-scattering Swift model [8], which can also derive the dielectric constant from the degree of polarization. All six quasi-specular + diffuse model combinations were fit to the data to find the best dielectric constant, rms tilt angle, and scattering albedo.

We note that the rms tilt angle is measured at the wavelength scale (centimetric) and could be due for example to coarse gravel. Although absolute values of these parameters are model-dependent, the relative values from one terrain to another indicate real variations in surface properties.

South of Selk crater, observations at very similar incidence angles but different look angles were acquired on the same area during two flybys (T61 and T95). The dunes appear morphologically different (thinner in T61): this is most likely caused by the local local slopes of the dune side facing toward or away from the radar, thus changing the local incidence angle. The side facing the radar thus appears brighter, and is easily confused with the radar-bright interdune regions. To verify whether the observed anomaly in  $\sigma^0$  is caused by changes in azimuth or incidence, we examined the variations in  $\sigma^0$  with both of these parameters, in the dunes and interdunes separately.

#### Results and interpretations:

- Dunes exhibit the same microwave scattering properties both inside and outside Selk crater, indicating likely aeolian infilling bringing the same materials into the crater as are available elsewhere.
- The dune fields and especially the dunes within them have a low dielectric constant (between 1.5 and 2.2 median values for all models) consistent with previous work [e.g., 6, 9, 10], a low rms tilt angle compared to other terrains, and little diffuse backscatter. These properties all point to organic sand. Meanwhile, the interdune regions have a higher dielectric constant, indicating a likely icier and/or less porous surface.
- The effective dielectric constants derived from the quasi-specular and diffuse models agree in the dune fields: the assumption of a smooth surface with little subsurface scattering appears to be valid.
- The dark regions also have a low dielectric constant and little to no diffuse scattering. This is consistent with organic sand over depths thicker than ~1 m, and likely corresponds to a sediment sink due to converging winds or low topography.
- Azimuthal variability of dune brightness is observed between the overlapping T61 and T95 observations, confirming the presence of topography

and encouraging future application of azimuthal models such as used by [9].

**Conclusions:** The cm-scale smoothness and homogeneity of dunes makes them particularly well suited for simple backscatter models. Future work should examine on a global scale the dependence of backscatter with azimuth angle, which can reveal surface slopes and small structures such as ripples or avalanche sides, both linked to the wind regimes.

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**References:** [1] Turtle, E. P. et al. (2019), *50th LPSC*, Abstract #2132. [2] Lorenz, R. D. et al. (2021), *Planetary Science Journal*. [3] Soderblom et al. (2010), *Icarus* 208, pp. 905-912. [4] Malaska, M. J. et al. (2016), *Icarus* 270, pp. 130–161. [5] Bonnefoy et al. (2016), *Icarus* 270, pp. 222-237. [6] Wye et al. (2007), *Icarus* 188, pp. 367-385. [7] Hayes et al. (2011), *GRL* 44, pp. 11745-11753. [8] Swift et al. (1985), *JGR: Solid Earth* 90, pp. 1983-1994. [9] Le Gall et al. (2011) *Icarus* 213, pp. 608-624. [10] Lucas, A. et al. (2019), *J. Geophys. Res.: Planets* 124.11, pp. 3140–3163.

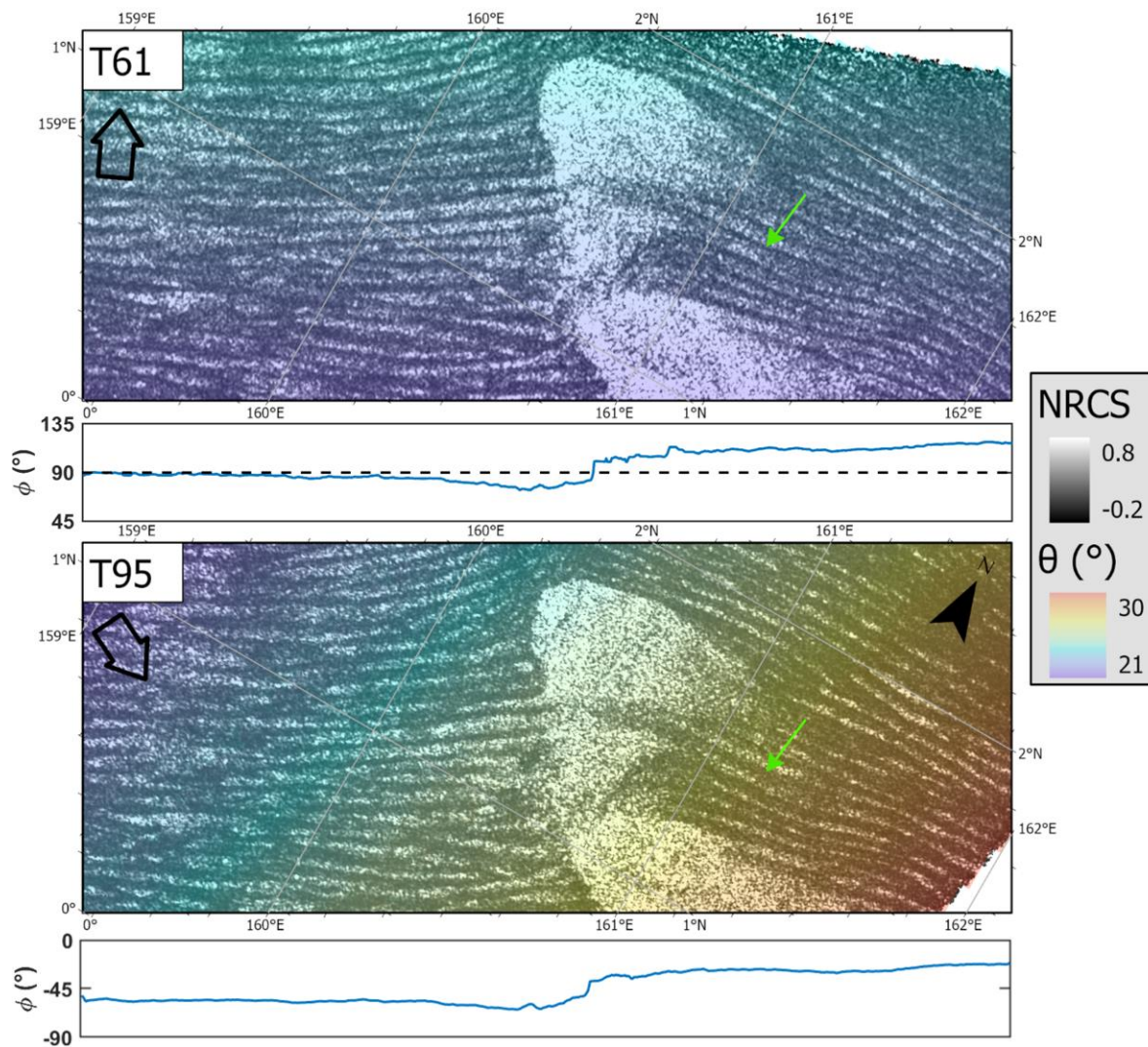


Figure 1: Comparison between the overlapping sections of T61 (top) and T95 (bottom) to the South of Selk crater. The incidence angle is mapped in color over the NRCS  $\sigma^0$ , shown in grayscale. The look direction of each swath is shown by the black arrow on the left. The light green arrow points to the same dune in both swaths; like many nearby dunes, it appears thinner in T61 than in T95. The azimuthal angle (CCW angle between the dune crest orientation and the look angle) is averaged in the y-direction of the image, and plotted below each image. For T61, it is around  $90^\circ$  as the dunes are near perpendicular to the look direction.