TITAN'S DUNES BY THE NUMBERS. A. Le Gall[1], S. Rodriguez[2], A. Garcia[2], J. Radebaugh[3], R.D. Lorenz[4], R.M.C. Lopes[5], A. Hayes[6], E. Reflet[2], [1]Laboratoire Atmosphères, Milieux, Observations Spatiales (LATMOS-UVSQ), Paris, France. [2]Laboratoire AIM, Université Paris Diderot, Gif sur Yvette, France. [3]Department of Geological Sciences, Brigham Young University, Provo, UT. [4]Johns Hopkins University Applied Physics Laboratory, Laurel, MD. [5]Jet Propulsion Laboratory, Caltech, Pasadena, CA. [6]Department of Earth and Planetary Science, University of California at Berkeley, CA.

Introduction: Thousands of dunes observed on the surface of Saturn's moon Titan were one of the greatest surprises uncovered by the Cassini spacecraft [1]. Dunes point to the mobility and processing of sediments on Titan – they are the telltale signatures of wind at work. As such, they provide crucial insights into the geology and climatic history of Titan. Being likely mainly composed of solid organics, they also hold clues on the methane and carbon cycles on Titan. In this paper, we will put numbers on dune areal coverage, volume, altitude and latitude distribution and show how these numbers can help understand past and present conditions on Titan.

Dune coverage Dune fields are one of the dominant landfoms on Titan. Using all SAR swaths acquired from the beginning of the mission (from Ta through flyby T77), we have outlined the dune fields of Titan (see Fig. 1). We find that they cover 6.5% of the 48.5% of Titan's surface observed by SAR so far. This suggests that the dunes may be present on as much as ~13.5% of Titan's surface which corresponds to an area of ~10 million km^2, that is roughly the area of the United States. For comparison, the seemingly featureless plains on Titan likely cover 14.2% of the surface while the hummocky radar-brigth terrains (including the puzzling Xanadu region) extend over 17.6% of the surface observed by SAR.

Next step will include the global mapping of the dune fields using VIMS (Cassini Visual and Infrared Mapping Spectrometer) dataset.

Dune volume Assuming 100 m-high dunes, accounting for the variability in dune height (30-180m, [2,3]) and dune/interdune area coverage fraction (25-50% as derived from [4]) and considering a maximum thickness for the interdune sand cover of 5 m, we find that the volume of sediments in the dune fields should be within the range 0.5-5×10^5 km^3 which represent an equivalent layer of ~0.6-6 m covering Titan. The sand budget is therefore most probably higher than the volume of liquid hydrocarbons on Titan which is currently estimated to be ~0.3×10^5 km^3, accounting for the up-to-date distribution of the lakes and seas, assuming a conservative depth of 20 m (as proposed by [5]) and neglecting a potential subsurface reservoir. If dune sand-sized particles are mainly composed of solid organics as suggested by VIMS observations [2] and atmospheric modeling and supported by radiometry data [6], dune fields are the largest known organic reservoir on Titan.

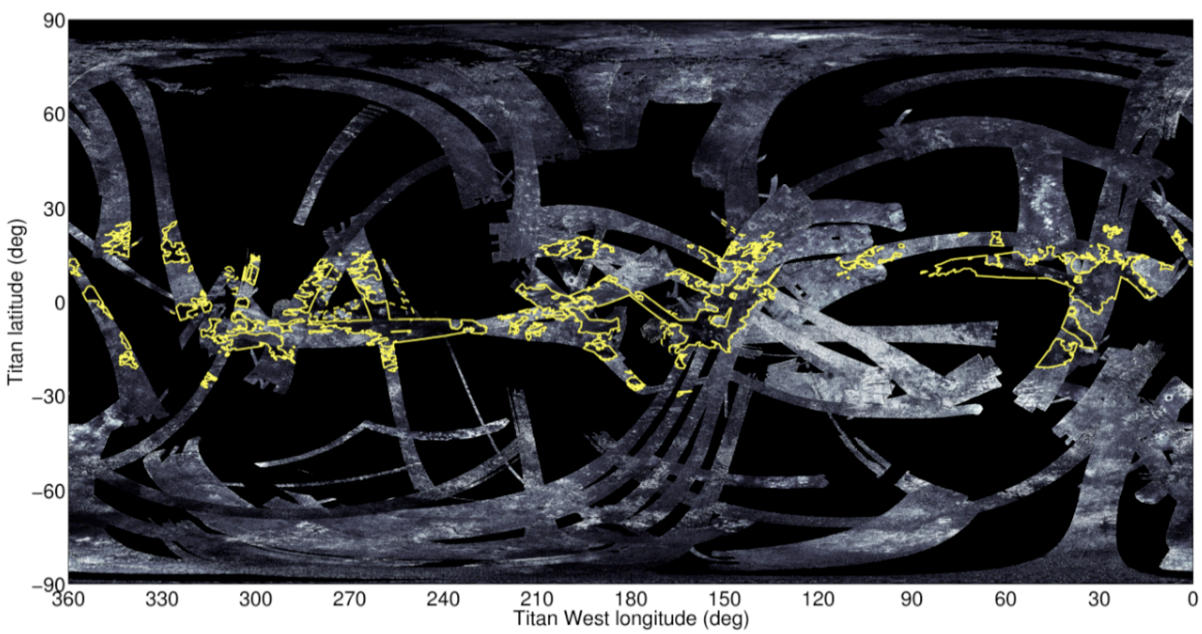

Figure 1: Mosaic of the Cassini SAR (Synthetic Aperture Radar) swaths. Dune fields are outlined in yellow. They are confined to the Equatorial belt.

Dune altitude Using the SAR-Topography data [7], we have investigated the height distribution of Titan's dune fields. The hypsometric profile of the dune regions extends from ~-400 m to ~200 m with a center of mass of ~-163 m and a 95% interval of confidence of 352 m (see Fig. 2). None of Titan's dune fields are located in the most elevated areas where the rate of erosion by aeolian or pluvial processes [8] may exceed the rate of sediment deposition. Neither do dune fields occur in the lowest terrains on Titan where the surface may be moist due to interaction with a potential subsurface alkanfer (hydrocarbon analog of an aquifer) thus limiting or inhibiting sediment entrainment. However, excluding Xanadu, which is relatively low for unknown reasons and whose nature is still puzzling, the center of mass of the equatorial height distribution, ~-115 m (with a 95% IC of 397 m), is higher than the center of mass of the dune terrain height distribution. Dune fields tend to occupy the lowest regions in the equatorial belt; ~70% of the observed dune regions for which we have topographic information are below -115 m in elevation. In particular, Belet, Aztlan and the dunes north of Senkyo are hosted within topographic depressions that are a few hundred meters lower than their surroundings. Troughs or basins are natural depositional sinks which helps explain the presence of sand seas in these areas.

Dune latitude Fields of linear dunes are confined to Titan's equatorial belt, within 30°N and 30°S latitude (see Fig. 1). On Earth the majority of important sand seas are located in low latitudes hot desert. Important dune areas also occurs in the cold arid and semi arid regions. This suggests that relatively dry conditions may prevail at Titan's tropics.

Furthermore, [9] have shown a definite trend towards narrower or more widely separated dunes and thinner interdunal sand cover in higher northern latitude terrains. This latitudinal correlation could result from a gradual increase in the soil wetness toward the North. A wet soil is indeed less favourable to dune developpement since it requires stronger winds to move sand.

The persistence of a gradual rise in wetness toward the northern latitudes could result from Titan's current orbital configuration: Saturn's eccentric orbit coupled to Titan's solar longitude of perihelion causes southern summers to be both more intense and shorter than northern ones. The less intense northern summers reduce evaporation relative to precipitation, which may increase the dampness of the surface and may well explain the lake distribution dichotomy on Titan [10] as well as the dune morphometry asymmetry. Much like the Croll-Milankovitch cycles on Earth, the asymmetry in Titan's hemispherical seasons is expected to reverse as orbital parameters vary with periods of tens of thousands of years (~32 kyrs).

It remains that the variations observed among Titan's dunes are relatively small which suggests that they were all built at the same time, forming a single generation.

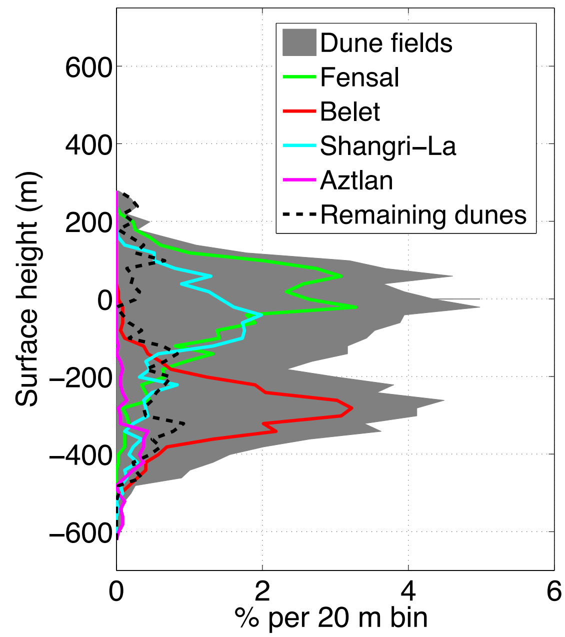

Figure 2: Surface height distributions (with a bin size of 20 m) of all considered dune terrains on Titan (gray), Fensal, Belet, Shangri-La and Aztlan dune regions. The dashed black line represents the height distribution of the remaining dune terrains. The surface heights are referenced to Titan's geoid as defined in [11].

References:

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