LONGITUDINAL DUNES ON TITAN : A LABORATORY APPROACH. E. Reffet[1], S. Courrech du Pont[2], P. Hersen[2], S. Douady[2], M. Fulchignoni[1]. [1]LESIA Observatoire de Paris (erwan.reffet@obspm.fr), [2]MSC CNRS-Université Paris 7.

Introduction: Cassini observations of Titan's surface revealed a features-rich body hidden behind its opaque atmosphere. The high spatial resolution (up to 300m/pixel) allows us to study large scale features covering its surface. Moreover, the great diversity of unveiled structures [1] make this planet-like satellite a geological object of interest.

Among these features, linear formations are geomorphologically similar to longitudinal dunes [2,3,4]. These longitudinal dunes observed by Cassini Radar (Fig.1) and Cassini VIMS cover Titan's equatorial regions and represent a large portion of the whole surface. Such constructions indicate a strong interaction between "sand grain"-size particles (typically about 200μm) and the winds close to the surface. As a consequence, the omnipresence of these dunes could help to constrain Titan's winds by understanding their processes of formation.

Fig.1: Cassini Radar Image of Titan's surface (T8, 2005). Linear features interpreted as longitudinal dunes appear ubiquitous in Titan's equatorial regions.

Albeit longitudinal dunes are the most commonly encountered type of dune on Earth, they have not been studied in details yet. The large scale of these aeolian features (km-scale on Titan or in the Namib Desert [5]) makes them not directly reproducible under laboratory conditions. We present here an original approach which allows us to reproduce longitudinal dunes in the lab, under controlled conditions. Based on this method, we study the evolution of an homogeneous sand bed under a bimodal wind regime and extend this laboratory work with numerical simulations.

Method: The physics of sand dunes is governed by the characteristic length $L_{Drag}=(\rho_p/\rho_f)*D_p$, where ρ_p and D_p are the density and the diameter of the sand grains used to form the dunes and ρ_f is the density of the fluid surrounding the dunes. This length corresponds to the characteristic distance at the end of which an eroded grain reaches the wind velocity [6]. In order to reproduce large scale aeolian patterns such as longitudinal dunes, we developed an under water experimental setup. The high density of water (in comparison to the atmospheric density on Titan or on Earth) decreases L_{Drag} and therefore reduces the size and timescale of the whole system. This method has already been used to produce and study cm-scale barchan in a lab experiment [7].

To create the wind, we use a baseplate which can be translated under water. We decided to move the sand bed relatively to the fluid rather than the opposite to minimize the size of the setup. The wind direction is modified by rotating the sand bed using a disk located in the center of the baseplate.

We start our experiments with an homogeneous sand bed. The sand (ceramic grains) is spread on the disk to avoid any privileged direction. The wind conditions consist of a bimodal wind regime, where the wind switches successively between two given directions. The angle between these two directions can be tuned from one experiment to another and we explore the influence of this angle on the evolution of the sand bed.

A numerical model is used to investigate the same initial conditions and wind regimes. This model is macroscopic and derives from the behavior of a fluid flow at the surface of a bump[8].

Experimental and numerical results can be compared and confronted to the observations.

Results: We present here (Fig.2) the different patterns obtained for various angles between the two directions of the bimodal wind regime. We report both the laboratory and numerical results for three characteristic states.

The left hand side pictures correspond to the laboratory experiments and the right hand side to the simulations results. For each picture, the mean wind direction is from the bottom to the top. The arrows indicate the two distinct directions of the bimodal wind regime. The angle between these directions increases from the top to the bottom panel.

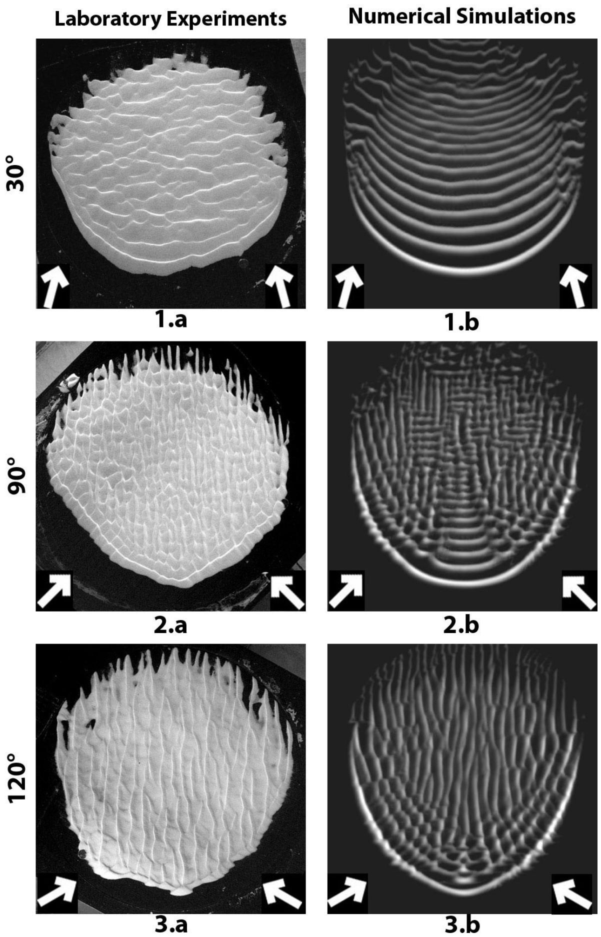

Fig.2: Type of structures obtained for various angles of the bimodal wind regime. For each angle, left picture (a) corresponds to the laboratory experiment (pictures are 30cm wide) and right (b) to the numerical simulation (scaled to be compared to the experiments). Arrows indicate the directions of the 2 winds : (1) 30°, Transverse dunes. (2) 90°, Intermediate pattern. (3) 120°, Longitudinal dunes.

For small angles (Fig.2.1): Dunes perpendicular to the mean wind direction developed on the sand bed. These dunes are usually called transverse dunes.

For intermediate angles (Fig.2.2): Features both perpendicular and parallel to the mean wind direction are formed. Transverse and longitudinal patterns are observed within the same sand bed. These patterns represent the transition from one type of sand bed to the other.

For large angles (Fig.2.3): Structures parallel to the mean wind direction are formed. This type of dunes is commonly called longitudinal dunes. They are morphologically similar to Titan's dunes (Fig.3).

This transition between transverse and longitudinal dunes, when increasing the angle of the bimodal wind regime, corresponds to a separation of the mean wind direction and the principal axis of mass exchange between structures [9].

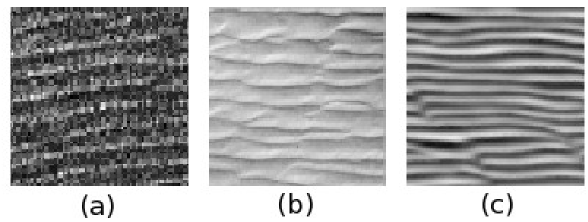

Fig.3: Comparison of longitudinal dunes morphology : (a) Radar image of Titan's surface. (b) Laboratory experiment results. (c) Numerical simulation results. These images are resized to a comparable scale.

Conclusions: We reproduced longitudinal dunes using a bimodal wind regime and under controlled conditions both experimentally and numerically. We also investigated the transition between transverse and longitudinal dunes and the link with the angle between the two wind directions. The presence of longitudinal dunes on Titan's surface as well as on Earth appears to be a good constrain on the local wind regime. Variations of wind direction of more than 90° appear to be required to produce longitudinal dunes. On Titan, the pervasive occurrence of these dunes in the equatorial regions could be an important constrain on Titan's wind model close to the surface[10].

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