CURVING LINEAR DUNES ON EARTH AND TITAN; IMPLICATIONS FOR TOPOGRAPHY.

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Introduction: Linear (longitudinal) dunes are the most abundant dune type on Earth [1], and also occur in a broad equatorial swathe on Titan [2,3]. Typically, these dunes, which form approximately parallel to net sand-tranporting winds under broad unimodal or bimodal wind regimes, are characterized by their length (up to ~10^2 km), regularity (often appearing at regular spacing of ~ 1-3 km) and consistent orientation over scales on the order of ~10^2 km [1]. They are known from terrestrial and planetary examples to deviate around obstacles (e.g. bedrock obstructions), by a feedback mechanism that enables changes to the dune's orientation even upwind of obstacles. Such 'topographic steering' is well reported from coastal dunes [e.g. 4], but has rarely been considered for desert dunes. The deviation of dunes close to obstacles has been observed and modeled for dunes on Earth and Titan, and orientation changes occur several kilometers upwind of the obstacle

In some rare instances, however – most notably in the Great Sandy Desert of northwestern Australia (Figure 1), and some of Titan's dunefields (e.g. Fensel; Figure 2) – the dunes have a distinctive, long-wavelength, curvilinear form without obvious obstructions to the boundary layer. We aim here to investigate the nature of these curvilinear dunes, and thus explore the drivers of this unusual patterning on Earth and the resultant inferences for Titan's dunes.

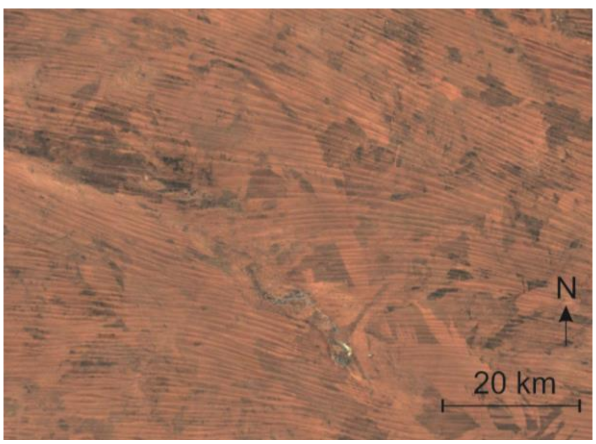

Figure 1. Linear dunes in the Great Sandy Desert show atypical deflections from the regional trend.

Methods: We use Landsat 8 data and the LIDO automated dune crestline detection algorithm [5], together with the Aster GDEM v2 digital elevation model, to delineate dune patterns of the Great Sandy Desert for spatial analysis. All analysis was performed within ArcGIS 10.3. The region of analysis extended from 19°-21° S and 122°-125°E, and covered approximately 70 000 km^2 of the dunefield.

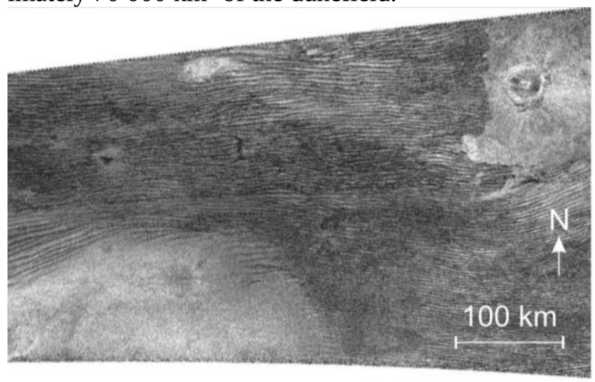

Figure 2. Similar deflections to the regional trend, without the necessary influence of obvious topographic obstructions, are seen in the Fensel dunefield of Titan.

Results: The automated detection routine identified 44,823 crestline sections in excess of 1 km in length (mean section length 2.1 km, maximum 39.7 km), with an example shown in Figure 3.

Deflection of the dunes was quantified by deviation from the mean regional trend of all dunes within the study area (281.4°; dune propagation in this region is controlled by the easterly trades of the continental anticyclone). This deviation from the regional trend is spatially discrete, and locally commonly diverges from the regional trend by up to 20° towards both the north and south.

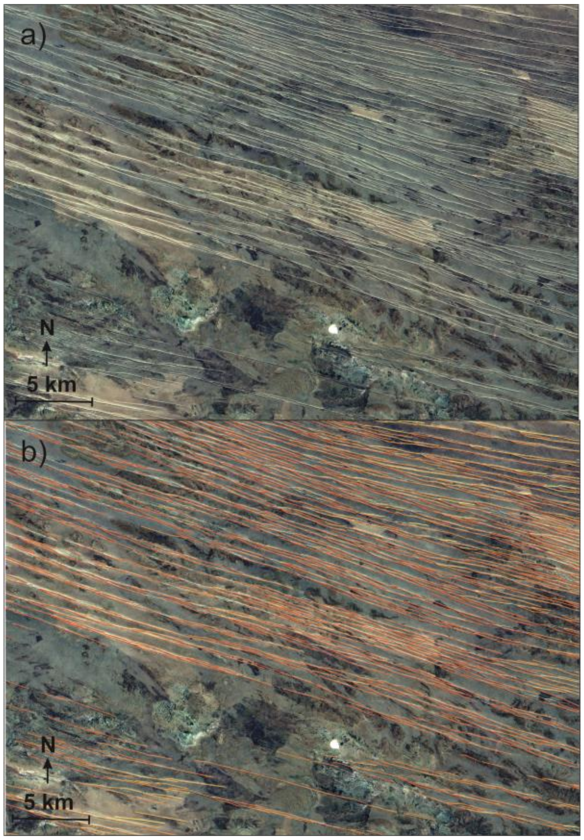

Figure 3. An example of the automated detection routine, with dune trendlines identified and shaded according to their orientation deviation away from a regional mean.

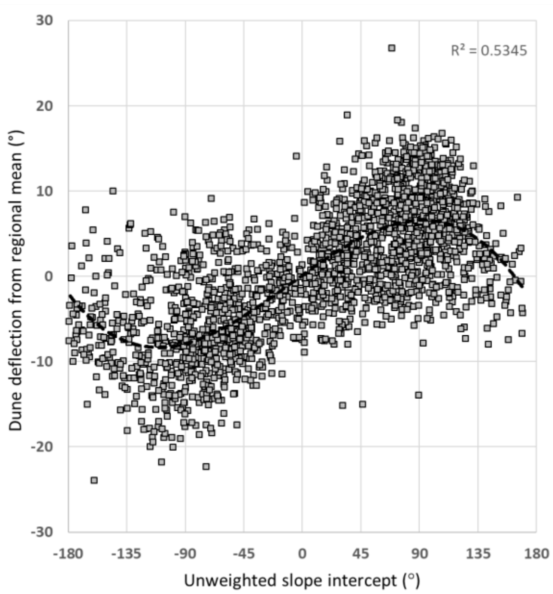

Figure 4. Plotting the slope intercept with the regional dune trend against the resultant dune deviation reveals the influence on slope orientation. The cubic fit reflects the maxima in deflection at +/-90°.

Discussion: Such deflection is shown to be controlled by the topography; the Aster GDEM data show that there is approximately 200 m of relief associated with the valley of the Mandora palaeodrainage. Dunes deflect northwards on encountering north-facing slopes, and southwards on encountering south-facing slopes; that is, in each case, they are deflected downslope. This effect is maximized when the incident slope is approximately orthogonal to the regional dune trend (Figure 4). Furthermore, such correlations are enhanced when the orientation of the slope is weighted by the magnitude of the gradient.

We discuss the implications of this finding for a) terrestrial dune geomorphology and b) topographic inferences that can be extended to Titan's dunefields, and conclude that spatial analysis of dune patterning offers the scope for detecting relatively subtle variation in underlying topography which may not be readily detected by other methods, on this world and others. The orientation of large linear dunes is not only controlled by broad patterns in the atmospheric boundary layer, but they also respond to the underlying topography they rest on. We explore the mechanisms by which this influence is controlled.

References: [1] Lancaster (1995) Geomorphology of Desert Dunes. [2] Lorenz et al. (2006) *Science 312, 724-727*. [3] Radebaugh et al. (2010) *Geomorphology 121, 122-132* [4] Bauer et al. (2012). *Earth Surf Proc Landforms* 37, 1661-1677. [5] Telfer et al. (2015). *Aeolian Res* 19, 215-224.