NAMIB ANALOGS TO TITAN DUNES : HIGH RESOLUTION SATELLITE TOPOGRAPHY

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Introduction: Since their discovery by Cassini [1], Titan's dunes have been an attractive target of scientific study, and large linear dunes on Earth, most notably in the Namib, have been used as an analog for them (see figure 1). Topographic study of these dunes has traditionally [2] been with isolated GPS profiles, or with satellite radar or stereo datasets with postings of 30m (e.g. ASTER – [3]). Radarclinometry, the same method initially used to estimate Titan's dune heights, has been applied to the Namib using Shuttle SIR-C data [4] at both its native resolution, and degraded to Cassini's 300m.

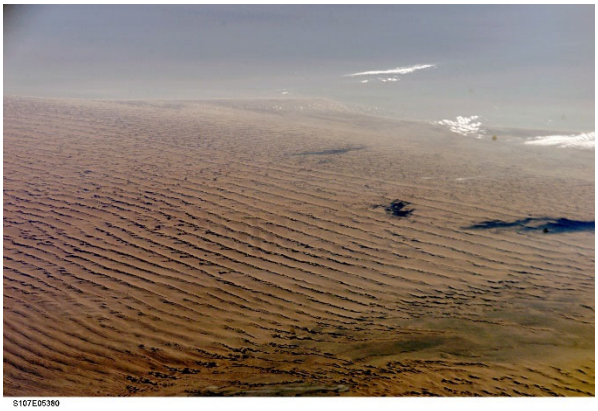

Figure 1. The space shuttle image of the Namib that was initially [1,2] key in recognizing Titan's linear dunes.This image was acquired on STS-107 and downlinked from orbit before the Columbia re-entry accident which occurred a few days later.

1m Resolution: While these previous data are adequate for overall geomorphological studies, the application of optical navigation and on-board terrain hazard assessment for future exploration of Titan by Dragonfly [5] demands higher spatial resolution for performance simulations. We have therefore acquired a commercial (Pleaides) satellite stereo digital elevation model (DEM) of a small section of the Namib (a 5x20km area at 24°19'S, 15°10'E previously studied by radar in [4]) to use as a Titan analog. The data (figures 2 & 3) have a posting of 1m.

In fact, data of this high resolution presents some challenges in our application, in that individual bushes can be detected and appear as 'steep' obstacles, whereas no such features are expected on Titan. Most of these features can be removed in processing. A further challenge is that stereo matching is difficult in feature-poor areas where the sand texture is uniform, introducing spurious hills and valleys.

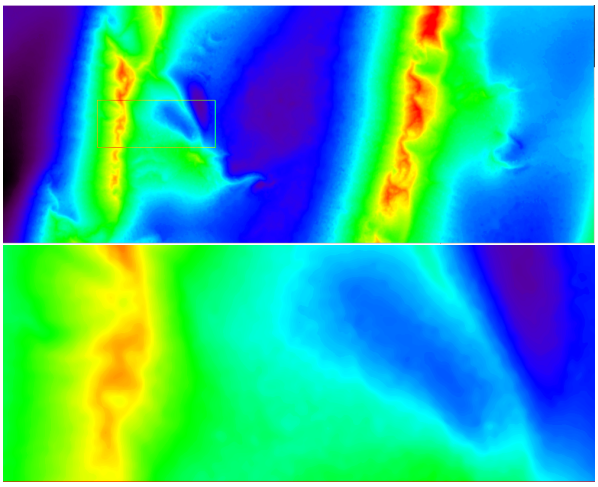

Figure 2. (top) a 5x2km section of the satellite DEM, showing the crest structure on two dunes. (bottom) zoom of a 1x0.4km section, showing the native resolution.

Simulations [5] with the DEM confirm that sand seas are replete with safe landing sites. While many hazardous locations exist (e.g., the data resolve slip faces very well – see figure 3), a large fraction of the terrain has slopes well within the capability of a lander.

Data like that shown here may be useful in other applications, such as simulating the radar reflectivity of dune topography: radar returns are sensitive to the unresolved surface roughness of the terrain [2,4].

References: [1] Lorenz, R. D. et al., The Sand Seas of Titan : Cassini RADAR observations of Longitudinal Dunes, Science, 312, 724-727, 2006 [2] Lorenz, R. D. and Zimbelman, J., 2014. Dune Worlds : How Wind-Blown Sand Shapes Planetary Landscapes, Praxis-Springer. [3] Bullard, J.E., White, K. and Livingstone, I., 2011. Morphometric analysis of aeolian bedforms in the Namib Sand Sea using ASTER data. Earth Surface Processes and Landforms, 36(11), pp.1534-1549.
[4] Neish, C. D., R. D. Lorenz, R. L. Kirk and L. C. Wye, Radarclinometry of the sand seas of Namibia and Saturn's Moon Titan, Icarus, 208, 385-394, 2010. [5] Witte, I.R. et al., 2019. No GPS? No Problem! Exploring the Dunes of Titan with Dragonfly Using Visual Odometry, AIAA Scitech Forum. AIAA-2019-1177.

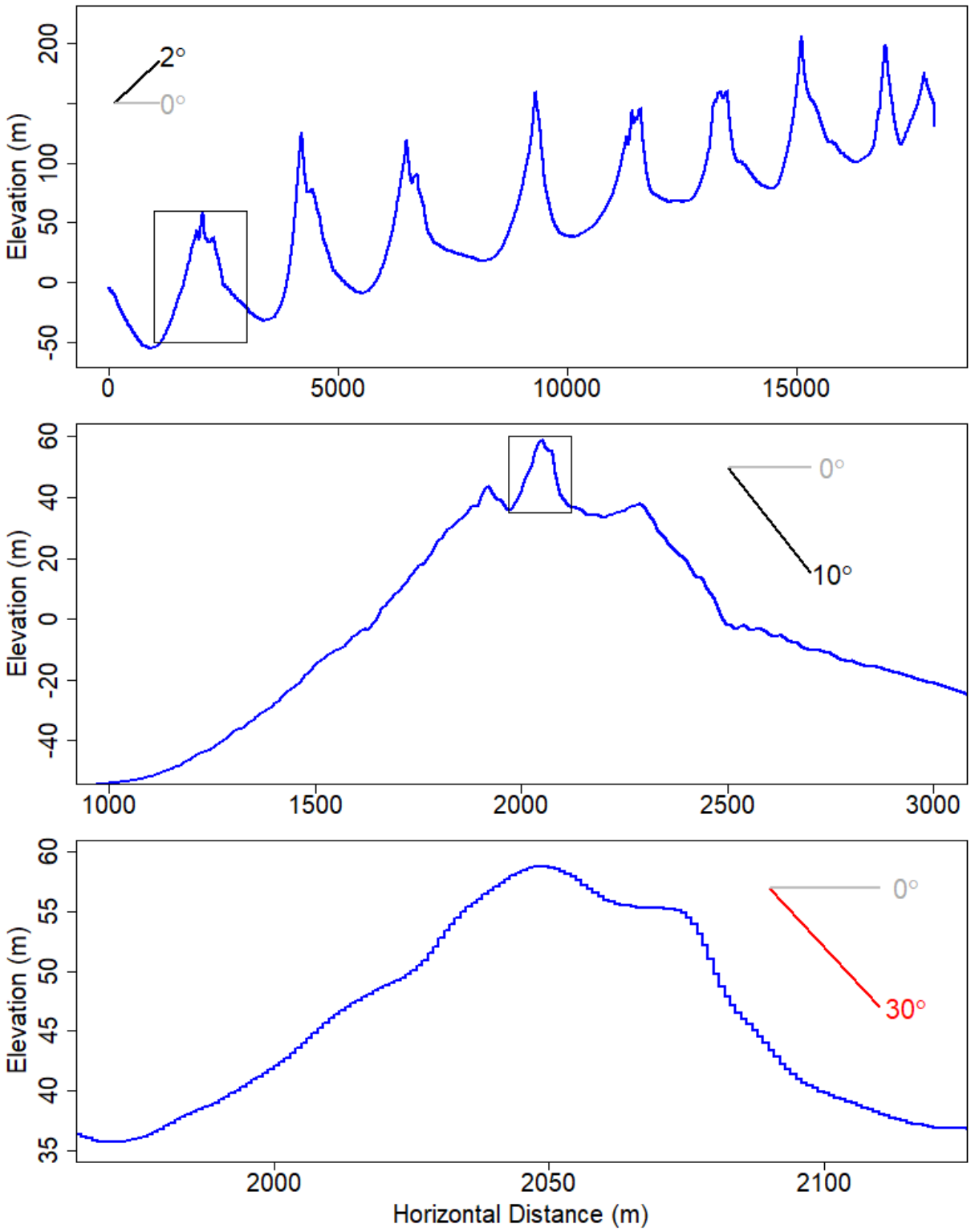

Figure 3 : (top) Profile across the domain – some 18km across, showing the regional slope and 8-9 dunes – box shows region zoomed in next panel. (middle) zoom of a single dune profile about 100m tall – a steep dune crest atop a broad summit is evident, as is a shallow dune plinth to the right. Box indicates region zoomed in next panel. (bottom) zoom of the crest, with stairstepping showing the individual 1-m posting of topographic heights. Part of the crest appears to be at or just beyond the classic angle of repose.