HEIGHTS OF FORTUNA-MESHKNET DUNES (AL-UZZA UNDAE), VENUS, FROM MAGELLAN RADARCLINOMETRY

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Abstract

We apply radarclinometric methods, first used for dune height estimation on Titan with Cassini data, to archive Magellan imaging of dunes. Estimates of ~40m height are obtained, suggesting the dunes are not 'fully-grown' perhaps due to sand supply limitations. The need for new, higher-resolution radar observations on Venus is noted.

1. Introduction

As discussed in [1,2,3] Venus has relatively few known Aeolian bedforms, in part perhaps due to a lack of sand-sized particles, and in part due to the limited spatial resolution of Magellan data. In Venus' dense atmosphere, saltation speeds are rather low, and thus one might expect Aeolian features to be present. It has been suggested [4] that widespread areas have small unresolved bedforms ('microdunes'), indicated by anisotropy in radar backscatter.

There are two major dunefields known [1,2,3]. The most prominent dunes are perhaps those in the Algaonice dunefield (Menat Undae) at 25^{o}S, 340^{o}E cover some 1300 km^2 at the end of the ejecta outflow channel from the Algaonice impact crater. The dunes are 0.5-5km in length and are quite bright, likely because there are slip faces oriented towards the radar illumination, which was at an incidence of 35^o**.** However, their shape is rather hard to determine and they are not considered further here.

The more northern dune field, Fortuna-Meshkenet, lies at 67^{o}N, 91^{o}E in a valley between Ishtar Terra and Meshkenet Tessera (the dunes are formally named Al-Uzza Undae). The dunes are 0.5-10km long, 0.2-0.5km wide and spaced by an average of 0.5km. They appear (figure 1) to be transverse dunes, in that there are several bright wind streaks visible in the region, which seem generally orthogonal to the dunes. Glints are not observed strongly on these dunes, although here the incidence angle of the radar observation was 22-25^o.

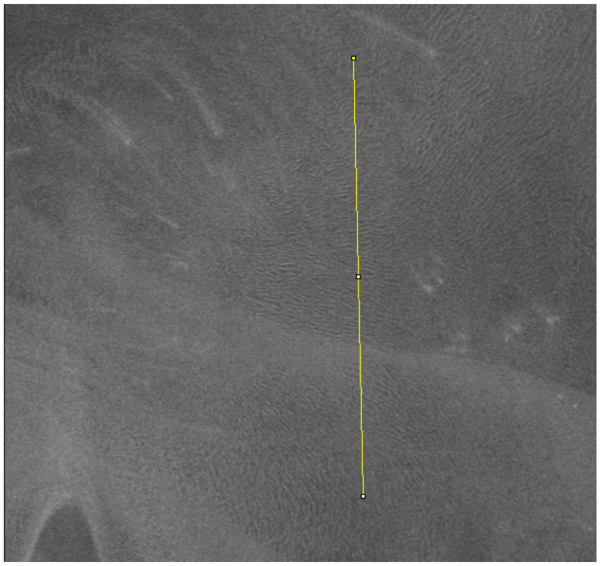

Figure 1. Dunes in the Fortuna dunefield (Al-Uzza Undae). Wind-streaks are prominent in the image, the dunes less so. Yellow line (36km long) is the profile examined in figures 2 and 3. Part of F-MIDR fr61n090.

2. Magellan Data

In contrast to typical Earth-observing radars, Magellan was in a highly elliptical orbit, and the range to Venus' surface, the incidence angle, and the image quality (SNR, resolution, etc.) are all functions of latitude (varying geometry is an even more prominent challenge for Cassini). Although the archive products are sampled at 75m spacing, the actual radar resolution at 25S is 135x120m (range x azimuth)with 7 looks and ~170x120m with 10 looks at 67N [5].

Examining the Muhleman function used to normalize the image, we find over the incidence angle range of interest, the backscatter variation with slope for 'typical Venus' is about 0.3 dB per degree. Thus we can convert the backscatter (fig.2) into a local slope estimate, and integrate along a profile to develop a height estimate. This approach was used to estimate the height of dunes on Titan when they were discovered [6], and has since been validated in Earth satellite observations of the Namib sand sea [7].

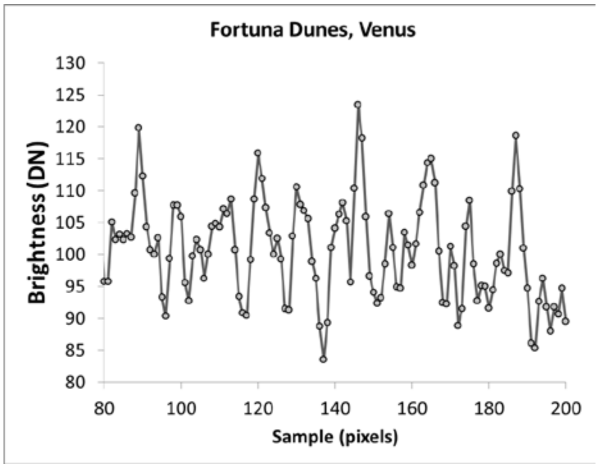

Figure 2. Magellan data product. The archived product is radar reflectivity relative to an assumed backscatter function

An example result is shown in figure 3. It can be seen that this small example has a dune wavelength of 1-1.5km and heights of 20-60m. (For comparison, Titan's dunes [6,7] have a spacing of 2-3km, and heights reaching 150m).

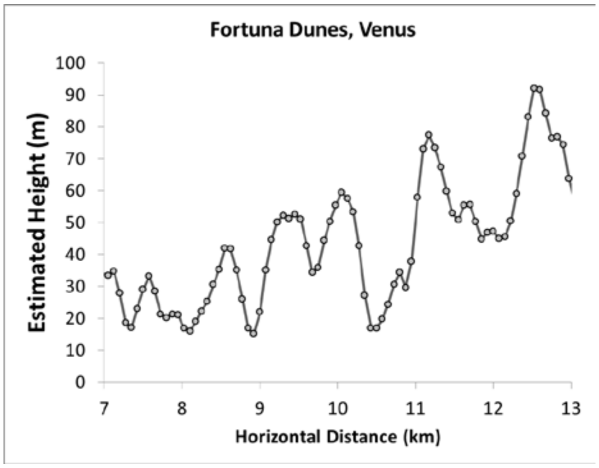

Figure 3. A radarclinometric profile.

3. Discussion

This aspect ratio (wavelength/height) of 20-50 is not as large as mature 'fully-grown' dunes which tend to reach ratios of about 12 [8,9], wherein the dune wavelength approaches the thickness of the atmospheric boundary layer. (We may note here that no in-situ measurements are presently available to define the thickness of the atmospheric boundary layer, but if maximum dune spacing is an indication, as it seems to be on Earth and Titan [8,9] , it may be 1~1.5km thick at this location.) It is possible the example shown does not capture the largest dunes in the field, but another interpretation is that these dunes are sand-supply-limited. That is of course consistent with Venus overall, where sediment-generating processes are suspected to be limited [2,3].

4. Conclusions

Clearly much work remains in the study of Venus dunes, but must await future radar observations with higher spatial resolution. Interferometric observations would be of interest to assess whether the dunes (or at least ripples/microdunes on them) are active. Although relatively comfortable for spacecraft landings, dunefields are unlikely to be prime targets for future missions (a question which might be reconsidered!). Future high-resolution in-situ temperature measurements during probe descents are also needed to define the atmospheric boundary layer thickness.

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