VENUS TOPOGRAPHY: A REAPPRAISAL

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The Pioneer Venus Orbiter (PVO) topography data set [1], which has served as the basis for virtually all subsequent geological and geophysical analyses of the planet [2-14] contains serious errors. Surface elevations were determined as the difference between the distance r of the spacecraft from the center of mass of the planet (determined from the Doppler shift in the S-band ground communications signal) and the height z of the spacecraft above the surface (determined from the round-trip light time of the radar altimeter signal). There are appreciable errors in both of these input parameters.

In the original processing of the altimeter data [1], no correction was made for the slower propagation of the radar signal through the massive atmosphere. As a result, the distance from the spacecraft to the planetary surface was overestimated, and thus the planetary radius was underestimated. The mean error is roughly 500 m. Since the scale height of the atmosphere is large (~15 km [15]) compared to the mean topographic variations (~1 km RMS [1,2]), this error can be corrected to first order by adding a constant to all of the elevations. However, there is an additional correction which is dependent on elevation. A revised PVO altimetry data set, which includes corrections for this propagation delay, has been compiled recently [16].

Another source of error in the topography is the estimated orbit of the spacecraft. The orbital information used in the initial processing of the altimetry data [1] consisted of predicted locations, which were generated at ~10 day intervals to aid in planning mission operations, rather than the best available post hoc estimates of where the spacecraft actually went. As a result of orbital errors, the available topography data sets [1,16] display conspicuous, fallacious lineations oriented along the orbit tracks (NNE at the equator, more nearly NE at high latitudes). A related problem is locating precisely the orbital position corresponding to the acquisition time of a given radar signal. A timing error of 25 ms will produce radial errors that range from 0 at periapsis to over 100 m at high latitudes (when the radial componenet of velocity is highest). Because of these problems, discrepancies between adjacent orbits can be as large as several hundred meters.

An effort is underway to correct these remaining errors in the topography. As a first step, the best available dynamic estimates of the orbital parameters [9] will replace the predicted orbits used heretofore. Subsequently, a nondynamic orbit correction procedure, similar to that used in correcting SEASAT orbits [17,18,19] will be employed to removed biases between adjacent and overlapping orbits. It is anticipated that the corrections due to this source will be relatively small, and not nearly as systematic as the propagation delay error.

To assess the seriousness of these changes, we have estimated coefficients of a spherical harmonic series representation of the new data set [16], which includes the atmospheric correction, but not the anticipated orbital improvements. In table 1 we compare the new data set with the previous topography data set [1,11]. Table 1 presents the correlation coefficients and spectral admittances of the new versus old topography data sets for harmonic degrees from 1 to 18. This analysis indicates that at these relatively long wavelengths, the two data sets are very similar indeed. The largest difference is in the mean radius (corresponding to harmonic degree 0). A similar comparison of the new data set with a recent analysis of the gravity field [20,21], confirms that geophysical inferences based on analysis of the old topography data set are unlikely to change significantly using the new data set. The geophyiscal implications of topographic changes associated with orbit error corrections are yet to be assessed.

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TABLE 1

Comparison of "new" and "old" topography data sets

Degree	Correlation	Admittance ("new"/"old")
1	0.9871	0.8205 ± 0.0939
2	0.9531	0.8472 ± 0.1346
3	0.9974	0.9630 ± 0.0286
4	0.9915	1.0988 ± 0.0509
5	0.9964	0.9901 ± 0.0267
6	0.9811	0.9259 ± 0.0527
7	0.9963	1.0388 ± 0.0241
8	0.9721	0.8991 ± 0.0542
9	0.9944	1.0097 ± 0.0254
10	0.9901	0.9407 ± 0.0298
11	0.9971	1.0048 ± 0.0164
12	0.9904	1.0208 ± 0.0290
13	0.9887	0.9794 ± 0.0291
14	0.9853	1.0535 ± 0.0345
15	0.9829	1.0131 ± 0.0346
16	0.9844	0.9534 ± 0.0301
17	0.9837	1.0084 ± 0.0316
18	0.9658	1.0288 ± 0.0461