SPECTRAL STUDY OF VENUS GLOBAL TOPOGRAPHY AND GEOID FROM MAGELLAN AND PVO DATA; A.B. Kucinskas and N.J. Borderies, Jet Propulsion Laboratory/ California Institute of Technology, Pasadena, CA 91109; D.L. Turcotte, Department of Geological Sciences, Cornell University, Ithaca, NY 14853.

We have conducted an analysis of newly available global harmonic models for topography and geoid on Venus. We find that the power spectral density for Venus topography has a power - law dependence on wave-number characteristic of Brown Noise, similar to what is found for the Earth. However, the Venus topography spectrum presents a rollover at lower degree (l=3) than is observed for the Earth spectrum and has smaller amplitudes than that of the Earth's. The Venus geoid also obeys a power-law relationship, at least for small values of l, but with a smaller slope and more power (for l> 3) than the Earth geoid.

With the gravity data gathering phase (cycle 4) of the Magellan mission well under way and the Venus altimetry data from Magellan being complete new, higher degree and order, spherical harmonic models of Venus gravity and topography have been produced. It is worthwhile to analyze these harmonic fields which have improved coefficient estimates and incorporate data from the Pioneer Venus Orbiter (PVO) and higher resolution data from the Magellan spacecraft. However, it is also important to note that the application of an a priori constraint (namely Kaula's law) to the estimation of the gravity harmonic coefficients makes any quantitative analysis of the higher degree parts of the resulting gravity power spectra unreliable at this point. In this work we thus performed a spectral study of the power spectrum resulting from a new spherical harmonic model for Venus topography and of the lower degree part of the spectrum from a harmonic model of the Venus geoid (equipotential surface) comparing the results to that obtained for Earth spectra.

For the gravity field we used a 60th degree and order spherical harmonic model (1) recently produced at the Jet Propulsion Laboratory and combining PVO and recent Magellan Doppler tracking data. We deliberately restricted our analysis of the geoid spectrum derived from this field to lower degrees ($l \leq 18$). The topography model we used was also produced at JPL (1); its spherical harmonic coefficients were computed by numerical quadrature from a grid of planetary radii derived from the complete set of PVO and Magellan altimetry data (2).

One standard practice is to expand global data sets on a planetary surface in terms of spherical harmonics; examples include geoid and topography (3,4). We define the degree variances of these spectra by:

$V_l^t = R_o^2 \sum_{m=o}^{l} (A_{lm}^2 + B_{lm}^2)$, for the topography and: $V_l^n = R_o^2 \sum_{m=o}^{l} (C_{lm}^2 + S_{lm}^2)$ for the geoid,

where R_o is a reference radius (mean equatorial radius for Venus), A_{lm}, B_{lm} and C_{lm}, S_{lm} are the non dimensional and normalized coefficients (of degree l, order m) for the spherical harmonic expansions of topography and geoid respectively. The C_{lm}, S_{lm} are the same as for the gravity potential and the geoid spectrum is obtained from the perturbing potential via Brun's formula (3). We can then define a power spectral density (PSD) for these expansions as: $P_l^t = 1/k_o \, V_l^t = \lambda_o V_l^t$ for the topography and $P_l^n = 1/k_o \, V_l^n = \lambda_o V_l^n$ for the geoid, where $\lambda_o = 2\pi R_o$ is the wavelength over which data are included in the expansions and $k_l = 1/\lambda_l = l/2\pi R_o$ is the wave number. Such spherical harmonic representations are said to be statistically scale invariant over a given range in wavelength if the PSD has a power-law dependence on wave number (4): $P_l \sim k_l^{-\beta}$, $-\beta$ being the slope.

In Figure 1 we show the PSD for global Venus topography corresponding to the spherical harmonic model we used, plotted against k_l in a log-log scale. We

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can see that the Venus data agrees quite well with a power-law spectral correlation, over a range $50 \geq l \geq 3$ (760 km $\leq \lambda_l \leq$ 12, 675 km), with β= 2 (dashed correlation line in Figure 1). This correlation is characteristic of Brown noise, with the amplitudes directly proportional to the wavelengths. Such a $\sim l^{-2}$ dependence of the PSD is also observed for Earth topography (5), where the height to width (ie aspect) ratios of mountains and hills are the same. For $l < 3$, the Venus topography spectrum shows a rollover. This is also observed on the Earth although the power deficiency starts at a higher degree ($l \sim 5$). Furthermore, when compared to Earth data (6,7), the Venus spectrum has significantly lower amplitude values which could be attributed to a weaker lithosphere over most of Venus (4).

The PSD for the Venus geoid data analyzed here also obeys a power-law, at least for $l \leq 18$. However, terrestrial geoid data (8), displays a larger slope consistent with Kaula's law ($P_l^n \sim k_l^{-3}$). Smaller geoid spectra slopes on Venus have been attributed to shallower gravity sources (9). Also, for $l > 3$, the PSD for Venus geoid shows larger amplitudes than for Earth data, a possible consequence of the significant correlation seen on Venus between gravity and topography (10).

Comparisons between the spherical harmonic expansions of gravity and topography on Venus can prove useful in probing the internal structure of the planet and testing evolution models predictions. However, Magellan data from the planned circularized orbit phase should greatly reduce the burden of an a-priori bias required to produce current high degree and order gravity harmonic models, thus significantly increasing the reliability of quantitative analysis of these data sets.

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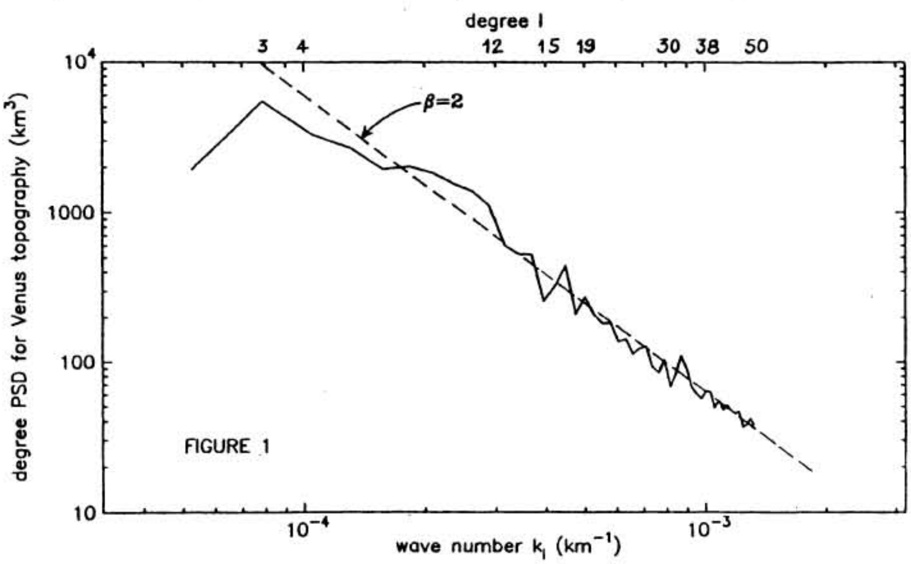

Figure 1. Power spectral density of Venus' topography as a function of wave number. The dashed line illustrates a correlation with a power-law for β = 2.

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