# SPECTRAL ANALYSIS OF THE GRAVITY AND TOPOGRAPHY OF MARS

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New spherical harmonic models of the gravity and topography of Mars place important constraints on the structure and dynamics of the interior. The gravity and topography models are significantly phase coherent for harmonic degrees $n \leq 30$ (wavelengths $\geq$ 700 km). Loss of coherence below that wavelength is presumably due to inadequacies of the models, rather than a change in behavior of the planet. The gravity/topography admittance reveals two very different spectral domains: for $n > 4$, a simple Airy compensation model, with mean depth of ~100 km, faithfully represents the observed pattern; for degrees 2 and 3, the effective compensation depths are 1400 and 550 km, respectively, strongly arguing for dynamic compensation at those wavelengths.

The gravity model has been derived from a reanalysis of the tracking data for Mariner 9 and the Viking Orbiters [1] The topography model was derived by harmonic analysis of the USGS digital elevation model of Mars [2]. Before comparing gravity and topography for internal structure inferences, we must ensure that both are consistently referenced to a hydrostatic datum. For the gravity, this involves removal of hydrostatic components of the even degree zonal coefficients [3]. For the topography, it involves adding the degree 4 equipotential reference surface [4], to get spherically referenced values, and then subtracting the full degree 50 equipotential.

Figure 1 illustrates the variance spectra of orthometric heights and gravity anomalies. Also shown for comparison are curves proportional to $\{n(n+1)\}^{-1}$with constants of proportionality (A,B) = (8,1) $10^{-7}$. The topographic and gravitational variance spectra of the Earth, Moon, Mars and Venus are all well appoximated by power laws of this sort [5,6,] . Note that this spectral form for gravity represents a steeper decay than is implied by the usual "Kaula's rule" [7,8], but the constraint of finite variance requires asymptotic behavior similar to this.

The variance spectra only address the relative amplitudes of the gravity and topography signals. Another important means of comparing them is to examine their phase coherence. The degree correlation coefficient provides a means of examining this coherence. It is a normalized cross-variance. Figure 2 illustrates the correlation spectrum for gravity and topography of Mars, and the 99% significance level. The dip in coherence at degrees 4, 8 and 9 may be real feature of the planet, or may simply reflect errors in the gravity or topography models. In general, the topography is more prone to long wavelength errors, and the gravity is more prone to short wavelength errors. The *a priori* expectation for the high degree behavior is that the correlation should remain consistently high. The decline in coherence beyond degree 30 is likely due to errors in the gravity model, though it should be noted that the correlation is still significant out to degree 40. The peak at degrees 36-38 is due to a resonance in the Viking orbits that amplified signals at those degrees [9].

Figure 3 compares the empirical gravity/topography spectral admittance with the theoretical values expected for Airy compensation [10], with depths of (100, 200, 400, 800) km. Pratt compensation curves for depth 2d are virtually identical to Airy curves for depth d [11,12]. At harmonic degrees greater than 3, an Airy model with 100 km depth fits the observations quite well. However, degrees 2 and three require much greater depths. The implication is that the longest wavelengths are dynmamically supported [13].

References

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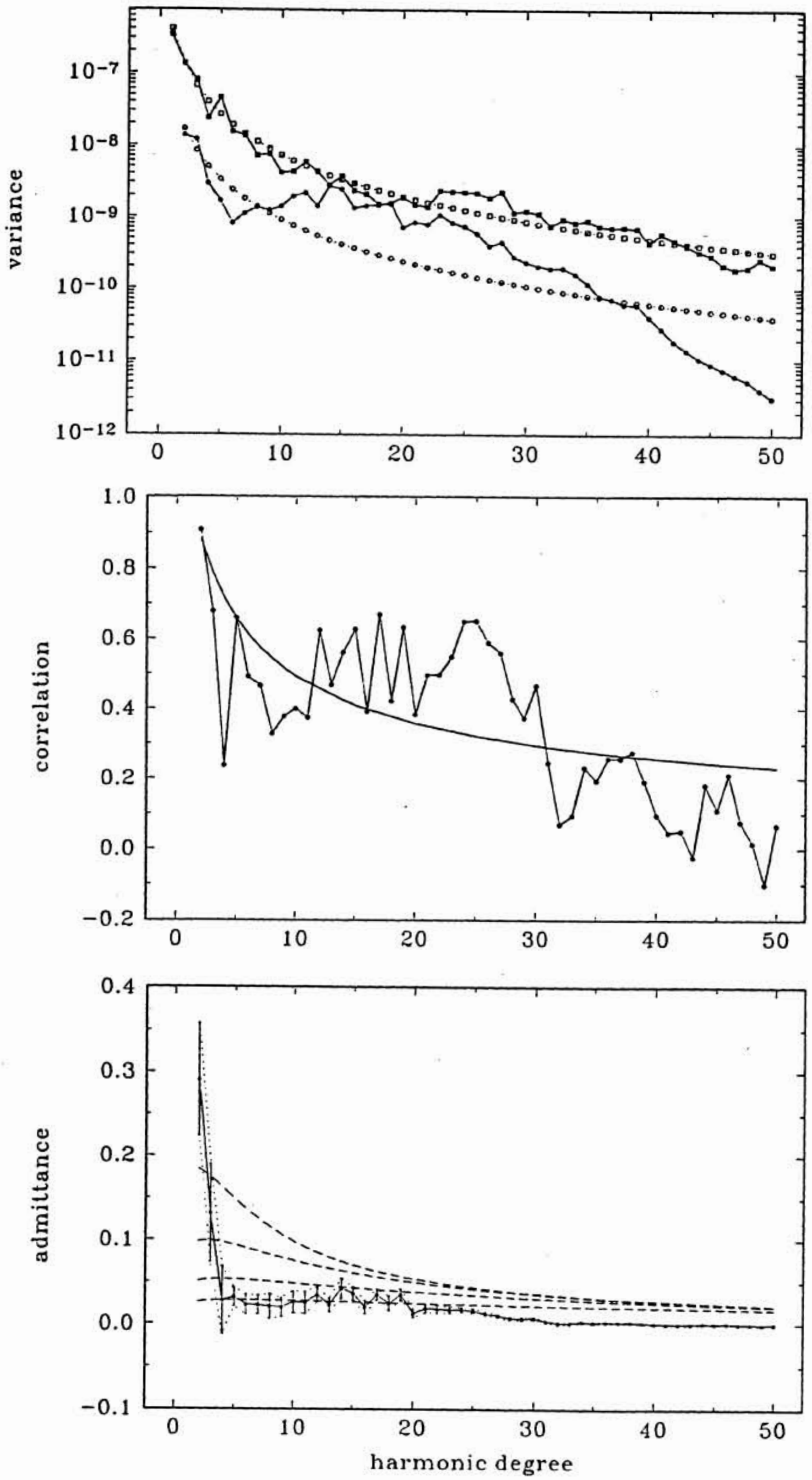

variance
10-7
10-8
10-9
10-10
10-11
10-12
0
10
20
30
40
50
correlation
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
admittance
0.4
0.3
0.2
0.1
0.0
-0.1
harmonic degree