SCATTERING PROPERTIES OF VENUS' SURFACE; R.A. Simpson, G.L. Tyler, M.J. Maurer, and E. Holmann, Center for Radar Astronomy, Stanford University, Stanford, CA 94305-4055

Radar backscatter functions $\delta_0(\phi)$ for incidence angles $0 \leq \phi \leq 40^\circ$ have been derived from Magellan altimetry radar echoes. The procedure includes constrained solution of a system of simultaneous equations for which the echo spectrum and echo time profile are inputs. A practical and workable set of constraints has been applied; optimization and improved results are expected as the analysis matures. The scattering functions yield information on small scale surface structure (tens of centimeters to tens of meters) but averaged over hundreds of km$^2$. RMS surface slopes derived from fits of analytic functions to the $\delta_0(\phi)$ results have been converted to map form and show patterns similar to those reported using other techniques. Fit residuals imply that an exponential scattering function matches data better than either the Hagfors or gaussian form in most areas, but that the Hagfors function may be preferred at the smoothest sites. Limited study of image data indicates that average backscatter cross section, and possibly its slope, can be derived at oblique angles ($17^\circ \leq \phi \leq 45^\circ$). Offsets of the echo peak in altimetry spectra are surprisingly common and are loosely correlated with Venus topography, but no cause for this phenomenon has yet been identified.

The observation that rms slopes obtained from direct inversion of the altimetry data are consistent, at least in a general way, with values derived from template fits [1] provides some confidence that both these procedures are reliable. Since the recovered functions $\delta_0(\phi)$ do not depend on a priori specification of an analytic function, we expect to find differences between our results and those obtained via the template method as our analysis proceeds.

Our result that an exponential scattering function provides better agreement with data than the widely used Hagfors function is significant in terms of its implications for the surface. Although the difference is not large, it is convincing. A gaussian surface model is derived by assuming that the surface is gently rolling. A Hagfors surface must have at least a few flat segments and some "edges" in order to justify use of an exponential autocorrelation function. For many planetary surfaces this seems plausible in the sense that gravity, through the action of different kinds of erosional processes, tends to level the surface while disruptive events such as impact events and volcanic eruptions leave irregular blocks and ragged edges exposed. The degree to which a fresh planetary surface has been turned over may be seen in the degree to which its scattering is described by gaussian functions rather than Hagfors functions. The exponential function requires that there be more flat lying segments than even the Hagfors function requires. We note that while the exponential law works best for Venus, just the opposite is the case for the Moon [2]. It seems likely this difference reflects underlying differences in processes of erosion and deposition and of materials on the two bodies.

Our results from SAR image analysis to date are limited. We have found a smooth region (in altimetry data) east of Alpha Regio where SAR backscatter cross section is lower than predicted by the Muhleman function, suggesting that the same scattering mechanisms apply at both nadir and at $\phi=30-35^\circ$. East of Maxwell SAR backscatter is above average, but our estimates of rms slopes and those derived from template fitting [3] indicate that this is an "average" region in its nadir backscatter. The difference could be accounted for by the presence of small-scale roughness which is not apparent to the altimeter but scatters relatively strongly at oblique angles.
The Doppler offset observations appear to be real and a manifestation of a geophysical or geological state of the surface. They show global patterns which include a great circle at equatorial latitudes (roughly following the band of equatorial highlands which includes Aphrodite Terra, Eistla Regio, and Beta Regio) and at least part of another (constant latitude) circle at 40-50°N. Large scale surface slopes from Pioneer Venus topography [4] correlate to some extent but are inadequate by themselves to cause the displacements observed. Small-scale "shingles" or other asymmetric scattering surfaces (for example, sand dunes [R.A. Arvidson, personal communication]) could contribute, but acquiring independent confirming data will be difficult. Local slopes of 0.3° on kilometer scales may also be important [P.G. Ford, personal communication], but more needs to be learned of their distribution. A concentration of negative offsets between Sapas Mons and Rusalka Planitia, where the large scale surface gradient is perpendicular to the Magellan track, indicates that this phenomenon need not be associated with large-scale slopes. Global-scale "zones of disruption" [5] may have led to surface modification which is not expressed as large-scale topography.

References: