VENUS SURFACE PROPERTIES IN MAGELLAN RADAR ALTIMETER DATA: RESULTS OF PRINCIPAL COMPONENT ANALYSIS. N. V. Bondarenko[1, 2] and M. A. Kreslavsky[1], [1]Earth and Planetary Sciences, University of California - Santa Cruz, 1156 High Street, Santa Cruz, CA, 95064, USA (nbondar@ucsc.edu), [2]IRE, NAS of Ukraine, 12 Ak.Proskury, Kharkov, 61085, Ukraine.

Introduction: The Magellan radar altimeter results potentially contain more information about the Venus surface properties than shown in widely used global maps of roughness and reflectivity (the GSDR and GReDR data sets) [1]. An attempt to improve interpretation of surface scattering behavior at six locations through the fitting of near-nadir Magellan backscatter data with a linear combination of two conventional scattering laws has been presented in [2]. However, the shape of the backscattering function has never been used in geological studies of the surface of Venus. Here we present our results of application of principal component analysis to near-nadir Magellan backscatter measurements and demonstrate that the shape of the backscattering function is useful for classification of the venusian surface properties.

Source data: The presented work is based on the analysis of the backscattering function solution [3] archived in the PDS as a part of the SCVDR data set. These data have been used in geological analysis to assess asymmetry of unresolved surface topography [4]. The data are arranged as individual points along Magellan orbits; each data point obtained from analysis of 5 consecutive radar bursts. The backscattering function has been estimated [3] for a set of incidence angles from 0.25° up to ~11° (depending on latitude) with 0.5° interval.

Data processing: We performed principal component (PC) analysis of the backscattering solutions from SCVDR within several selected regions on Venus. As a rule, we see that there are 3 – 4 PCs that contain some signal above the noise level; low or high values of a PC often form contiguous areas and apparently correspond to some specific materials and textures on the surface. Below we present our results for one of the studied areas.

Example of the results: The study area (Fig. 2a) spans 11°S – 27°S, 55°E – 80°E. It comprises volcanic plains of Tahmina Planitia, reaches of Ovda Tessera in the north and Xi Wang-mu Tessera in the southern and south-eastern parts. Impact crater Bassi (35 km in diameter) in the center has an expressive radar-dark parabola; crater Elena in the eastern part has a radar-dark halo. This area has 7009 backscattering function solutions, each resulted from 5 consecutive radar bursts from 787 - 921 Magellan orbits of the 1st cycle of the survey. Each solution contain 15 points for incidence angles up to 7.5°.

Fig. 1 shows primary results of the PC analysis. Fig. 1a shows the eigenvalues of the correlation matrix. The first 3 PCs contain 59%, 17%, and 6% of the total backscattering function variability. The eigenvalues above the 5th follow exponential decline and are entirely noise. The 3rd and might be 4th components are above this trend and potentially contain information.

The 1st PC is a weighted average of the backscatter over the whole range of incidence angles (Fig. 1a); it characterizes the overall intensity of returned echo. Not surprisingly, the spatial distribution of PC1 intensity (Fig. 2d) correlates very well with that of estimated Fresnel reflectivity (Fig. 2b). PC1 map (Fig 2d) shows nicely that the radar-dark parabola and halo have generally high reflectivity; it is also seen that the extent of this high-reflectivity material (Fig 2d) is wider than that of the radar-dark features in the SAR images (Fig. 2a) like [5]. It is interesting that a piece of tessera inside the parabola in the NW part of the scene has higher PC1 than typical tessera and lower than typical parabola material in the plains. This means that the airfall deposit of high-dielectric material ejected by the Bassi impact is not continuous and some original tessera surface is exposed due to downslide motion of freshly fallen debris.

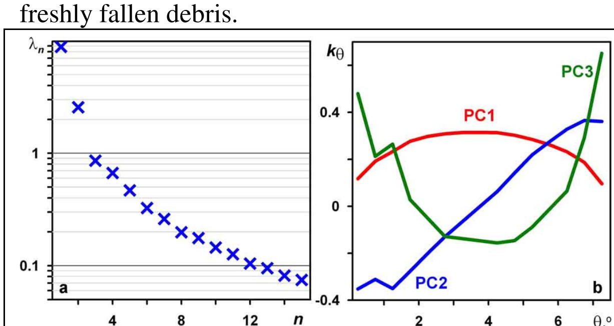

Fig. 1. Results of PC analysis for the region shown in Fig. 2. (a) eigenvalues of the correlation matrix; (b) loading coefficients of the first 3 PCs plotted against incidence angle.

The 2nd PC is a weighted balance between low-incidence-angle and high-incidence-angle parts of the backscattering function (Fig. 1b); high PC2 values mean relatively heavier tail of the backscattering function and therefore generally higher surface roughness. At the first glance , the correlation between the spatial distributions of PC2 (Fig. 2e) and retrievals of Hagfors roughness parameter ξ (Fig. 2c) is not very strong: tesserae and ridge belts have high ξ, but moderate (and noisy) PC2 values. This occurs because of low general reflectance of these terrains and the linear nature of the PC. On high-reflectivity plains, however, the correlation is higher; all low-ξ areas have low PC2 values. The PC2 map nicely shows that the inner part of the parabola with parabola-related slope streaks in the images is rougher than streak-free peripheral parts. This may indicate the presence of gently-sloping aeolian bedfoms in this area. Patches of high-PC2 material on radar-bright plains have diffuse boundaries on the SAR images and probably also related to some surficial deposits.

The 3rd PC describes the shape of the bacscattering function in more details (Fig. 1b), in particular, it characterizes relative weighted balance between the middle part and distal tail of the backscattering function; high values of PC3 indicate the disproportionally abundant steeper unresolved slopes. The spatial distribution of PC3 (Fig. 2f) is noisy, which is not surprising given the low value of the corresponding eigenvalue (Fig.a). Despite the noise we see distinctive contiguous area of high PC3 in the central-northern part of the scene. The surface unit is distinctive from other smooth plains by the presence of more prominent small-scale inhomogeneity.

Conclusions: In addition to the two parameters of amplitude scale (which is related to the Fresnel reflectivity) and general width (which is a measure of general roughness), the Magellan altimeter data set contains some more potentially useful information about unresolved surface topography.

References: [1] Ford P. G. and Pettengill G. H. (1992) *JGR, 97*, 13,103– 13,114. [2] Sultan-Salem A. K. and Tyler G. L. (2006) *JGR, 111*, doi:10.1029/ 2005JE002540. [3] Tyler G. L. et al. (1992) *JGR, 97*, 13,115– 13,139. [4] Bondarenko N. V. et al. (2006) *JGR, 111*, doi:10.1029/2005JE002599. [5] Bondarenko N. V. and Head J. W. (2004) *JGR, 109*, doi:10.1029/2004JE002256.

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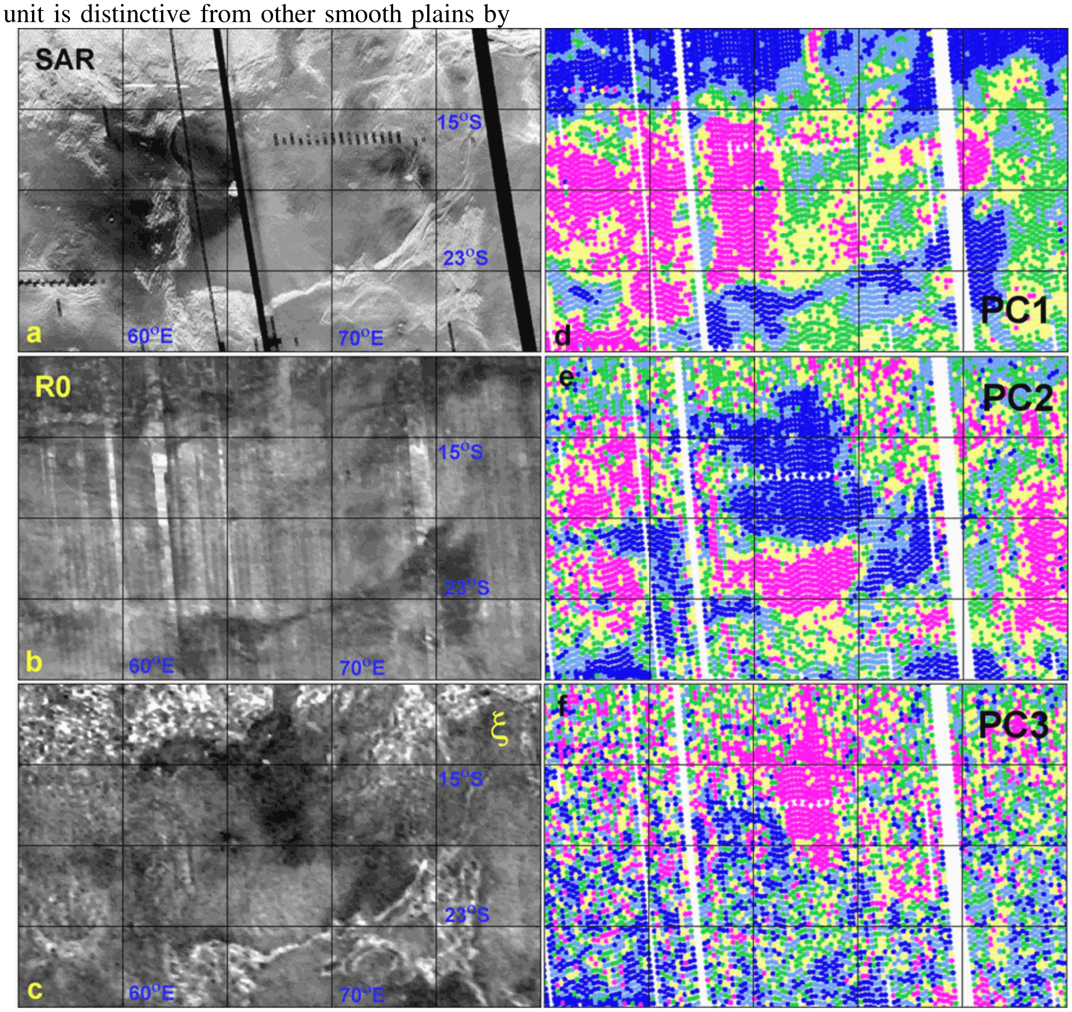

Fig. 2. Portion of Venus surface (11ºS – 27ºS, 55ºE – 80ºE) with crater Bassi (left) and crater Elena (right): (a) SAR image; (b) Fresnel reflectivity *R*0; (c) Hagfors roughness parameter ξ; (d) distribution of first principal component PC1; (e) distribution of second principal component PC2; (f) distribution of third principal component PC3. Brighter shades in (a), (b) and (c) mark higher values. Dark blue, light blue, green, yellow and pink colors in (d), (e), and (f) mark values from low to high, 20% of the total number of data points per color.