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Venus surface and near surface anomalies on the Northern hemisphere observed by VIRTIS/VEX: First results

G. Arnold (1,2), R. Haus (2,3), D. Kappel (1,2), A. Basilevski (4), P. Drossart (5), and G. Piccioni (6)

(1) Institute for Planetology, Westfälische Wilhelms-Universität Münster, Münster, Germany (Gabriele.Arnold@dlr.de), (2) DLR, Institute of Planetary Research, Berlin, Germany , (3) Astrofeinwerk GmbH, Berlin, Germany , (4) Vernadsky Institute, Moscow, Russia , (5) LESIA, Observatoire de Paris, CNRS, UPMC, Universite Paris-Diderot, Meudon, France , (6) Instituto di Astrofisica Spaziale e Fisica Cosmica, Rome, Italy

Venus nightside emission measurements of VIRTIS on Venus Express provide the opportunity of surface studies in the narrow near infrared atmospheric windows. The measurements as well as detailed new radiative transfer simulations show that radiance ratios in the emission windows between 1.0 and 1.35 μm with respect to the 1.02 μm window can be used to extract information about the surface elevation and temperature. Based on these analyses, first surface and near surface anomalies are identified on the Northern hemisphere of Venus, which are due to deviations of the elevation - temperature correlation in certain small areas.

The data are selected from VIRTIS-M-IR nightside measurements. To ensure minimal atmospheric influence on the measured signatures, only pushbroom observations with small observation angles close to nadir are taken into account. The radiative transfer simulation technique considers absorption, emission, and multiple scattering by gaseous and particulate constituents of the atmosphere. Look-up tables of quasi-monochromatic gas absorption cross-sections are calculated using appropriate spectral line data bases and line profiles and a line-by-line procedure. Empirical continuum absorption coefficients are determined from a 'VIRTIS reference spectrum'. In order to derive the parameters of the H_2SO_4 clouds, Mie theory is applied. Multiple scattering is considered by a Successive Order procedure. The synthetic quasi-monochromatic intensity spectra at the model top level of the atmosphere are convolved with the VIRTIS spectral response function.

The surface windows at 1.02, 1.10 and 1.18 μm exhibit a clear dependence of transmitted radiation on topographical features and, thus, on surface thermal emission, since an elevation change of 12 km results in a temperature change of 100 K. In the first approximation, the radiance ratios are affine linear functions of the surface temperature. This is demonstrated by both measurements and simulations. In general, the ratio-based VIRTIS topography correlates well with the Magellan topography, but differences occur in localized areas.

Different local surface anomalies do exist. These anomalies are probably a result of the lower atmosphere dynamics, errors in Magellan elevation determinations, or variations in the surface emissivity. Surface emissivity variations are important indicators of the nature of surface material. They may be due to variations in mineralogy and surface texture. While most of Venus' geologic units are thought to be basaltic in composition, some of them (tessera terrains) could be felsic. The 1 μm emissivity of felsic materials is lower compared to basalts at similar texture conditions. Nevertheless, we found that anomalous areas comprise practically the same geologic units as adjacent non-anomalous terrains.

The surface texture (grain size, packing density, surface roughness) is another important factor for emissivity anomalies. Grain size affects the spectral characteristics. Laboratory measurements of basalts and oxidized basalts show significant changes in the contrast of the 1 μm reflectivity band. Although most of the surface of Venus is not very rough, roughness variations exist. Tesserae and rifts show a higher surface roughness compared to other areas.

Finally, the Magellan radar data that represent the base of the topography information of the Venus surface result from a surface layer of about 1 m in thickness, whereas the VIRTIS-NIR data describe the optical upper surface layer only.

The radiative transfer simulations show the capability of our algorithm to investigate the surface of Venus. Based on these simulations and the VIRTIS/VEX measurements, the extracted anomalies are discussed in the framework of these processes and influences mentioned above. Future improvements will contribute to eliminate the masking of the Venus nightside windows by far wing and pressure-induced absorptions of the deep atmosphere constituents. This will allow a better separation of deep atmosphere, temperature, and emissivity contributions to the Venus nightside emission.