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Mapping the surface of Venus in Near-Infrared

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Abstract

Venus Express is an ESA spacecraft orbiting Venus since April 2006. The instrument VIRTIS acquires multispectral images in the range from 0.2 to 5 μm wavelength. An analysis of VIRTIS images of the atmospheric windows at 1.02, 1.10 and 1.18 μm shows evidence for variation of surface emissivity on the southern hemisphere. The emissivity of rock or soil in the NIR range is sensitive to its mineral composition and grain size distribution. The surface is subject to weathering, which may alter both mineral composition and grain sizes. Therefore the surface emissivity has the potential to give evidence of original rock composition as well as weathering processes and their effective duration. Mapping the emissivity might give clues about rock forming processes or surface age.

Data Processing

The window at 1.02 μm is relatively broad and has a high surface to atmosphere ratio. Data processing is less difficult than at the other two windows and yields the best results so far [1]. Bands 0 and 30 of VIRTIS -M IR image cubes, accessible at the ESA planetary science archive PSA `http://www.rssd.esa.int/psa` , are corrected for stray-sunlight and limb darkening to retrieve flux of radiation emitted through the windows at 1.02 μ and 1.31 μm. Cloud transmittance is determined from 1.31 μm and applied to 1.02 μm while accounting for multiple reflections between lower atmosphere and clouds [2, 3].

The remaining contrast is highly correlated with Magellan altimetry. Owing to the greenhouse climate the surface temperature can assumed to be constant temporally albeit steadily decreasing with surface elevation [4]. The combined effect of surface temperature and extinction is analyzed empirically as the average behavior of 'declouded' flux with respect to topography and wavelength sampled. Thus characterized average flux establishes a relation between VIRTIS brightness, wavelength and topography. Fig. 1 is a mosaic of all processed VIRTIS images translated to topography and fits well to Magellan GTDR data. Spatial resolution is limited by scattering in the cloud layer to 100 to 120 km, see also [5, 2].

The residual of radiance after removal of the global trend with Magellan altimetry is positively correlated with emissivity and is used as basis for surface studies. The data processing is currently extended to the other two windows.

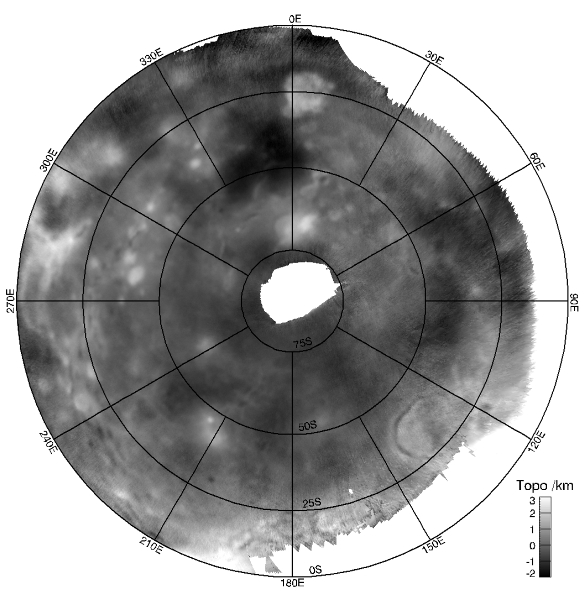

Figure 1: VIRTIS NIR measurements are calibrated with Magellan topography and band wavelength to yield topography.

Observations

The emissivity variation inferred is to some extend correlated with geomorphological features established from Magellan radar images. Most general result is that tessera highlands have a tendency to emit less than than other highland areas of the same altitude.

Some, but not all volcanic edifices show increased emissivity. Large lava flows in the Lada

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terra - Lavinia planitia region also show an increased thermal emission. In particular Cavilaca and Juturna fluctus, emanating from Boala corona (70S 0E) inside Quetzalpetlatl corona, are characterized by an increased IR flux [6].

In the preliminary analysis of all three windows the digitate flow fields associated with Ubastet fluctus and Kallistos vallis show a relativ red spectral slope.

Interpretation

In situ measurements by the Venera and Vega landers are at most places consistent with basaltic surface composition. The hypsometry of Venus is unimodal. Inferred lava viscosity of most volcanic features is low, consistent with basaltic composition. All these observations hint towards a crust mostly composed of basalt [7]. However, no landing site was on tessera terrain, tessera are hypsometrically elevated and the morphology is dominated by tectonic deformation. Among other arguments this leads to the hypothesis that tessera highlands crust is more abundant in feldspar and silica, comparable to lunar highlands or continents on Earth [8]. A recent study suggests that topography and and tectonic structure of tessera are best explained by less dense crust withstanding recurring global subduction events [9].

NIR mapping supports this hypothesis [10, 1], although other interpretations of the NIR data can not be ruled out. The Magellan radar altimetry does not fully resolve the topography of tessera terrain and additionally the altimetry is much less reliable at tessera terrain. The Magellan altimetry has to be reduced in spatial resolution to fit the VIRTIS data and the uncharted complex topography might lead to a biased results.

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