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Properties of particles in the upper clouds of Venus in the UV-dark and -bright regions as retrieved from the UV and near-IR VMC/VEx images

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Abstract

The nature of ultraviolet contrasts observed on the upper cloud deck of Venus is still not known. To constrain better the properties of particles that may cause the UV contrasts, the phase dependences of brightness of the Venus clouds measured by the UV (0.365 μm) and near-IR (0.965 μm) channels of the Venus Monitoring Camera (VMC of the *Venus Express* mission) in the UV-dark and -bright regions are jointly analyzed. It was found that:
(1) Variations in the composition of submicron particles in the clouds play a key role in the UV contrasts at low latitudes near the local noon. (2) In the pairs of UV-dark and -bright regions, the sizes of the 1-μm mode of cloud particles are the same. (3) The radius of particles in the upper clouds at mid latitudes decreases with latitude: from 1.05-1.2 μm at ~36°S to 0.8-0.9 μm at ~62°S. (4) An additional amount of nonabsorbing 0.9-μm particles at the cloud top produces the UV-bright bands at ~50°S.

1. Introduction

The range of small phase angles, where the glory phenomenon is observed, is of key importance for the phase-function analysis of the clouds composed of liquid aerosols, because the angular position and the shape of this feature allows of reliable estimates of the properties of spherical particles. Our previous papers were focused on the near-IR (NIR) profiles [1-3], since the interpretation of the data for shorter wavelengths meets the problem of a large number of unknowns (a noticeable contribution of submicron particles and the presence of absorbing material in different modes of cloud particles). At the same time, it was shown that the joint analysis of UV and NIR phase profiles may yield useful results. Unfortunately, only in ten orbits of the mission the images were taken simultaneously in UV and NIR channels at small phase angles. The measured phase profiles were fitted with the radiative-transfer models that took into account (i) the submicron particles of different composition homogeneously mixed with the 1-μm mode in the clouds and (ii) the overcloud haze.

2. UV contrasts near the equator

We selected the pairs of small UV-dark and -bright regions (0.2°x0.2°) observed at approximately the same phase and zenith angles, i.e., their different brightness cannot be caused by different observational conditions. Then, the brightness of these regions in two channels was traced along the whole set of images of the orbit, which yielded the phase profiles (Fig. 1, upper thick profiles).

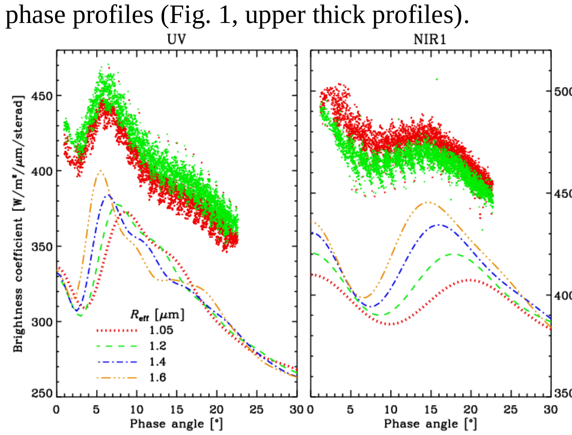

Figure 1: The phase profiles measured in the UV and NIR channels for the groups of UV-dark (red) and -bright (green) regions between 5°S and 10°S (orbit #2146). The UV-dark regions are brighter in NIR. The single-scattering models (thin curves below) are presented for several particle radii (the refractive index is 1.51+0.00005i and 1.46+0.0i for 0.365 and 0.965 μm, respectively).

Since the position of a glory strongly depends on the particle sizes, a comparison of the measured phase profiles with the single-scattering phase functions of spherical particles immediately yields the estimate of the radius of cloud droplets. The humps in the phase profiles measured for UV-bright and -dark regions are at the same angular position (Fig. 1), which indicates the same sizes of cloud particles mostly contributing to the scattering at the probed level in the UV-dark and -bright clouds. In the equatorial region near the local noon, the derived radii of cloud particles turned out to be rather high, 1.3-1.6 μm.

No unambiguous connection between the UV contrasts and the NIR brightness was found. In some cases, the regions that appear contrasting in UV show no difference in NIR. This means that the properties of 1-μm mode particles are the same there and only the contribution of submicron particles differs. The difference in the composition of 10% of the number of submicron particles (sulphur versus sulphuric acid) is enough to produce the observed UV contrasts. In the other cases, the UV contrasts are accompanied by the NIR brightness differences, which suggests that the cloud particles of the 1-μm mode also contribute to these contrasts. However, the modeling showed that exactly the variations in the composition of submicron particles produce a key effect on the UV contrasts observed. Moreover, a portion of submicron particles with a high refractive index, when incorporated into the sulphuric acid aerosols during the condensation process, may provide the higher (relative to that of sulphuric acid) refractive index for the 1-μm mode particles derived from modeling.

3. UV-bright strip at 50°S

The images with glories acquired in the so-called transition region, where a wide UV-bright strip divides mottled clouds at low latitudes and quasi-laminar flow at higher latitudes, are of special interest. To analyze the properties of particles in this strip, the phase dependences for the regions located along several meridians were built (Fig. 2, upper sets of symbols).

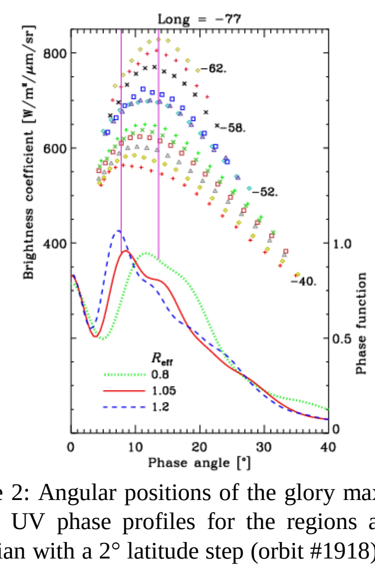

Figure 2: Angular positions of the glory maxima observed in the UV phase profiles for the regions along the -77° meridian with a 2° latitude step (orbit #1918) are compared to those in the single scattering phase functions (lower curves, right axis) calculated for sulfuric acid droplets of different radii.

Practically all of the phase profiles of the meridian sets, where the glory maximum can be found, show that it moves to larger phase angles for the regions at higher latitudes. This means that the size of particles in the upper clouds decreases toward the pole in the considered latitude range (Fig. 2). Moreover, a sharp increase of brightness in the bright band often occurs with no change of the particle sizes (the maximum remains practically at the same angular position). The modeling with varying properties of particles (of both submicron and 1-μm modes) in the clouds and in the above attached haze confirmed that the profiles for a the UV-bright belt can be well described only by the models containing the 0.9-μm particles in the main upper clouds or in the overcloud haze.

4. Summary

1. Variations in the composition of submicron particles, that inhabit the clouds together with the 1-μm mode, play a key role in the UV contrasts observed at low latitudes near the local noon.
2. In the pairs of UV-dark and -bright regions, the sizes of the 1-μm mode of cloud particles are the same.
3. The effective radius of particles in the upper clouds at mid latitudes decreases with increasing latitude: from 1.05-1.2 μm at 35-40°S to 0.8-0.9 μm at 60-62°S.
4. An additional amount of nonabsorbing particles about 0.9 μm in radius at the cloud top produces the UV-bright bands often observed at ≈50°S.

Acknowledgements

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References

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