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Multiwavelength imaging of Venus on Venus Express: correlation between the atmospheric dynamics, thermal structure, clouds, and the UV absorber

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Abstract

Simultaneous observations of Venus at wavelengths from the UV to the thermal IR with Venus Monitoring Camera and Visible and Infrared Thermal Imaging Spectrometer onboard Venus Express allowed us to reveal relationships between the atmospheric dynamics, thermal structure, clouds, and the UV absorber.

1. Introduction

From earlier observations Venus brightness has been known to vary strongly with wavelengths. This has had an obvious explanation in that different physical processes are responsible for the formation of the outgoing radiation at different wavelengths: UV markings are caused by the unknown UV absorber in the upper cloud layer, thermal-IR view including the hot polar dipole and the cold collar is a reflection of the thermal structure of the atmosphere, e.g. 5µm images give the temperature at the cloud tops, and the complex featured near-IR night side view (2.3, 1.74, 1.18, 1.1, 1µm) is related to variations of the total optical depth of the clouds and their properties and/or, depending on the particular “window”, to variations of the surface thermal emission. In particular, dark features at 1.74 µm mean higher cloud optical depths, and vice versa, bright regions — thinner clouds. Thus, these “faces” of Venus have been considered to have origin in different enough altitudes to be dynamically decoupled and their characteristic features to be generally uncorrelated. Venus Express observations allow us to observe Venus simultaneously in the spectral range from the UV to 5 microns and first time revealed the correlation between the pictures seen in the UV and IR [1, 2]. Here we further develop on these studies and present a detailed compilation of the available data. Scientific payload of the Venus Express includes 2 experiments with imaging capabilities: Venus Monitoring Camera (VMC) [3] and Visible and Infrared Thermal Imaging Spectrometer (VIRTIS) [4]. VMC is a 4-channel wide angle CCD framing camera taking images at 365, 513, 965, and 1000 nm. A moderate resolution subsystem of VIRTIS (VIRTIS-M) includes two channels with the spectral range from 0.3 to 1 µm and from 1 to 5 µm.

2. Results and discussion

The UV view of Venus can be reasonably explained by the thermal structure and dynamics of the atmosphere [2]. Mottled clouds at low latitudes indicate convective activity, which is supposed to bring the UV absorbers up from the depth making this region relatively dark (Figs. 1-2). On the contrary, the thermal-IR image with the natural limb-darkening is very uniform, which means the absence of the local temperature variations at the cloud tops. Cloud structures seen at 1.74 µm are elongated along parallels and extend practically throughout the whole hemisphere, while in UV they form the “Y”-feature. The 1.74 µm night side images are also as a rule darker near the limb because of the increasing optical depth at higher emission angles. Sometimes, however, near limb regions are as bright as middle latitudes. At about 60° the temperature inversions of the cold “collar”, which is perfectly seen on 5 µm images, prohibits the convection and the supply of the UV dark material from lower levels. The UV bright polar hood, which often has maximum brightness in middle latitudes and sometimes extends as far as 30°, is often (but not always) asymmetric: in the morning it typically reaches lower latitudes than in the evening. This may be explained by the UV bright haze created on the night side and destroyed by the solar radiation during the day.

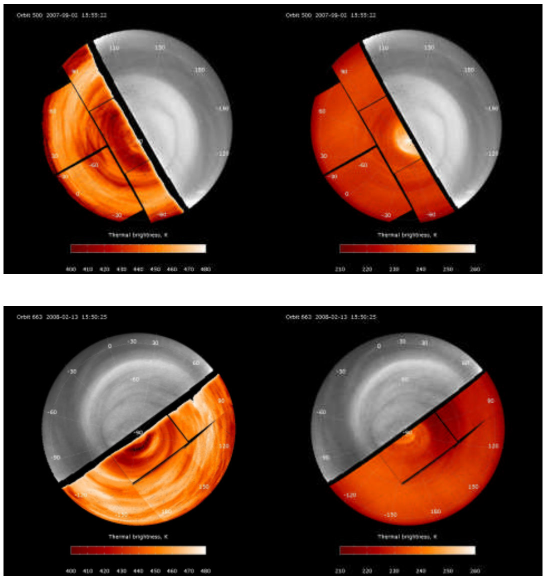

Figure 1: Examples of composite VMC & VIRTIS images: day side UV and night side 1.74 µm (left) and 5.02 µm (right). Note: 1) general view; 2) asymmetry of the brigh polar "hood".

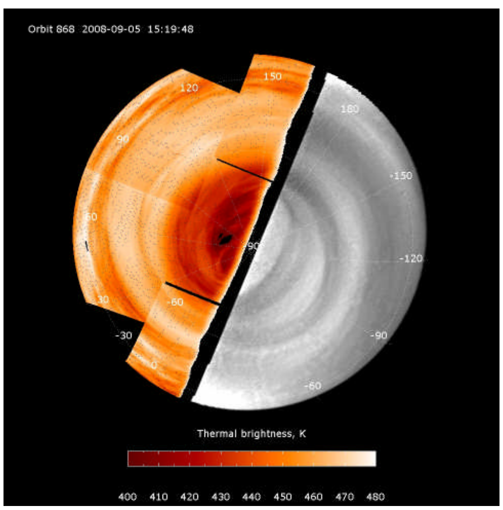

Figure 2: UV vs 1.74 µm. Note: continuation of the spiral structures from the dayside to the nightside

The near-IR brightness starts to decrease at 60°-70° implying an increase of the cloud optical depth. In the polar vortex, which is always warmer at the cloud top level than the surrounding cold collar, clouds are on average thinner. The hottest "eyes" of the vortex may look at 1.74 µm dark as well as bright. Although the images in the UV, at 1.74 and 5 µm are essentially different, there is a definite correlation between them. The hot spiral arms that take their origin in the vortex can be seen on the dayside as dark UV features, which extend down to 50° and even lower latitudes, and can be seen again in the night side 1.74 µm image throughout the whole hemisphere and sometimes again on the dayside in the UV. We suggest that these dark features are caused by the dynamical structures, which in the vertical dimension extend through the whole ~20 km cloud layer. It has been shown that the dark spiral arms do not correspond to gaps in the bright haze [5]. Similarly, they are often dark in the near-IR implying denser clouds.

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References

[1] Piccioni, G., Drossart, P., and 103 co-authors: South-polar features on Venus similar to those near the north pole, Nature, Vol. 450, pp. 637-640, 2007.

[2] Titov, D. V., Taylor, F. W., Svedhem, H., Ignatiev, N. I, Markiwicz, W. J., Piccioni, G., and Drossart, P.: Atmospheric structure and dynamics as the cause of ultraviolet markings in the clouds of Venus, Nature, Vol. 456, pp. 620-623, 2008.

[3] Markiewicz, W. J., Titov, D. V., Ignatiev, N. I., Keller, H. U., and 27 co-authors: Venus Monitoring Camera for Venus Express, Planet. Space Sci., Vol. 55, pp. 1701-1711, 2007.

[4] Drossart, P., Piccioni, G., and 29 co-authors: Scientific goals for the observation of Venus by VIRTIS on ESA/Venus Express mission, Planet. Space Sci., Vol. 55, pp. 1653-1672, 2007.

[5] Ignatiev, N. I., Titov, Piccioni, G., Drossart, P., Markiewicz, W. J., Cottini, V., Roatsch, Th., Almeida, M., and Manoel, N.: Altimetry of the Venus cloud tops from the Venus Express observations, J. Geophys. Res., Vol. 114, E00B43, 2009