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AKATSUKI-IR2 reveals unexpected opacity disruption affecting Venus's lower clouds every 9 days

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Abstract

The images of AKATSUKI acquired with the camera IR2 at 1.74-2.3 µm report the discovery of an equatorial disruption or "front" in the opacity of the lower clouds of Venus at 50 km between 30ºN–30ºS. This feature appears on the night every 9 terrestrial days during more than 8 months, and introduces a dramatic and abrupt increase of the cloud opacity and reducing the thermal radiance in a factor of about 1:2 from its brightest to the darkest side.

1. Introduction

The lower clouds of Venus, located at ~50 km, can be observed on the night side, mainly through the infrared spectral bands 1.74 and 2.30 µm which allow sensing the clouds' opacity to the deep thermal emission. Observations performed by the imaging spectrometer VIRTIS-M onboard ESA's Venus Express (VEx) [1,2] set that these lower clouds have different spatial scales at different latitudes, with larger and stretched features dominating from polar to mid-latitudes, while patchy and fine-scale structures being apparent at latitudes lower than about 40º [2]. In contrast to the upper clouds, the lower clouds features keep coherent longer (up to 6–7 hours), although for timescales of more than about 1 day the cloud opacity can change dramatically [3]. The prevailing circulation consists on less variable wind speeds with a magnitude similar to that found at the dayside upper clouds' deck at ~60 km [1]. They do not exhibit a clear mean meridional component, although VEx/VIRTIS-M observations were severely constrained to mid-to-high latitudes because of the polar orbit of VEx. Finally, nor the zonal neither the meridional component of the winds display any dependence with the local time [2].

2. Instrumentation

The successful orbit insertion of AKATSUKI in December 2015 [4] has implied a unique chance to continue the study of the mid-to-low clouds of Venus since the infrared channel of VEx/VIRTIS stopped its operations at the end of October 2008 after the end of the operative lifetime of the instrument cryocoolers. AKATSUKI began its regular scientific observations in April 2016, and the infrared camera IR2 [5] has continued studying the lower clouds of Venus thanks to a set of narrow-band filters with wavelengths 1.74, 2.26 and 2.32 µm. Among its scientific objectives, we can highlight the study of the atmospheric dynamics by measuring the cloud motion vectors, characterization of the morphology of the clouds, inference of the aerosol properties by combining 1.74 and 2.26-µm images, and mapping the CO concentrated below the cloud layer by differentiating 2.26 and 2.32-µm images [5].

3. Observations and Results

Up to date, IR2 has acquired more than 1,800 images of the nightside of Venus, covering from March 2016 until December 2016. The IR2 images have revealed that at lower latitudes the nightside deeper clouds of Venus exhibit a more dynamical behavior than at higher latitudes. Even though the period of rotation for the lower clouds is about 7 terrestrial days, the cloud patterns can become unrecognizable even after just 24 hours. A variety of new cloud features have been revealed thanks to the IR2 observations, including frequent shear-like structures, features resembling slowly developing vortices, or mesoscale packets waves even more abundant that at higher latitudes [6]. During the 27 of March 2016, a striking feature became apparent at equatorial latitudes, consisting a sudden change in the lower clouds' opacity extending between 30ºS–30ºN, and orientated with an angle of about 60º relative to the equator (Figure 1). From March to September 2016, this drastic change in the cloud opacity seems to follow the following 9-day cycle:

1. Once this disruption on the cloud opacity appears, it propagates slightly faster than the zonal flow and is followed by more opaque (darker) and homogeneous clouds.

2. The area of the darker clouds becomes gradually narrower, and its border with high-latitude brighter clouds adopts a wavy shape.

3. Finally, the equatorial dark area is invaded by turbulent patterns and small vortices. The disruption reappears again.

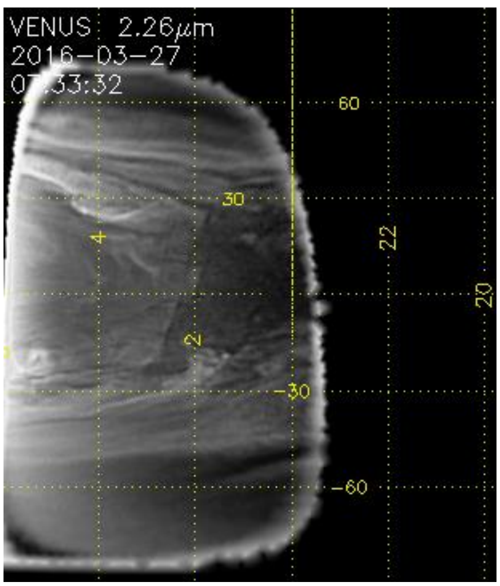

Figure 1: IR2 image of the disruption on the lower clouds' opacity during its first appearance.

4. Summary and Conclusions

Several candidates are proposed in order to explain this periodical change in the lower clouds' opacity, from the manifestation of an equatorially trapped wave to the formation of an atmospheric front from the interaction between masses of air with different properties (temperature, density). Recent analysis of past ground-based observations with telescopes has provided evidence that this phenomenon might be a recurrent cycle on the lower clouds beyond our period of observation with AKATSUKI. Also, the equatorial zonal winds experience a gradual increase in their magnitude up to a maximum of 30 m/s when the disruption is present. Both the cycle of changes in the cloud opacity and these disturbances on the zonal winds are being explored with a numerical shallow-water model [7] adapted to the conditions of Venus. Venus observations during the Galileo flyby [8] suggest that such a phenomenon might manifest also on the dayside upper clouds, so AKATSUKI/IR1 images at 900 nm will complement this work.

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