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Cloud top structure of Venus revealed by Subaru/COMICS mid-infrared images

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Abstract

We have investigated the cloud top structure of Venus by analyzing ground-based images obtained by the Cooled Mid-Infrared Camera and Spectrometer (COMICS), mounted on the 8.2-m Subaru Telescope. In this presentation, we will overview the observational results and discuss their interpretations.

1. Introduction

Venus is completely shrouded by a curtain of dense clouds (50−70 km) with total optical thickness of 20−40 at visible wavelengths. The upper sulfuric acid (H_2SO_4) clouds reflect ~76% of the incident solar radiation back to space [1]. Approximately 50% of the solar energy absorbed by Venus is deposited at altitudes higher than 64 km mainly due to absorption of unknown UV absorbers mixed in the upper cloud [2]. The resultant solar heating in the cloud layer excites thermal tides, which may play key roles in the maintenance of the atmospheric super-rotation [3]. In order to elucidate the momentum transport by thermal tides, it is fundamental to investigate the three-dimensional thermal structure in the cloud layer.

2. Observations

We conducted ground-based observations of Venus at two mid-infrared wavelengths (8.66 and 11.34 μm) with Subaru/COMICS, during the period of 25−29 October 2007 (UT). Thermal radiations at these wavelengths (brightness temperature: 230−240 K) are most sensitive to altitudes of ~70 km. The angular diameter of Venus and the solar phase angle (Earth-Venus-Sun angle) during the observation period were ~25” and ~90˚, respectively. The spatial resolution of images is ~200 km/pixel at the sub-observer point. These data are the highest spatial resolution images of Venus ever obtained in mid-infrared wavelengths.

3. Results

Figure 1 shows the brightness temperatures at 8.66 μm in the northern and southern high-latitude regions displayed in polar stereographic maps. These images suggest a possibility that the westward rotation of the polar features is synchronized between the northern and southern hemispheres. The possible synchronous rotation of the polar features has never been reported by any previous ground-based [4,5] and spacecraft [6,7] observations in mid-infrared probably because the low spatial resolution, the tilt of Venus’ north pole toward the Earth, or the restricted latitudinal coverage inhibited its detection. Figure 2 presents day-to-day variations of the residual patterns at 8.66 μm after the high-pass filtering. Streaks and mottled and patchy patterns exist over the whole disk and typically have amplitudes of ~0.5 K. It is noteworthy that all the features detected in Figure 2 can also be seen at 11.34 μm, suggesting that the features result from the inhomogeneity of the temperature and the cloud top altitude. Furthermore, the features have several common appearances with those observed in UV [8,9]. We demonstrate how the observed center-to-limb curves in the equator are sensitive to the production of the lapse rate and the cloud scale height above the altitudes of 60 km. Give the lapse rate in the range ~3−4 K/km [10], we can constrain the cloud scale height (2.4−4.3 km) and the cloud top altitude (66−69 km) from the center-to-limb analysis for data on 25 October, which support the previous results [7,11].

4. Summary

The mid-infrared observations with Subaru/COMICS provide valuable insights about the cloud top

structure of Venus. The possibility of the atmospheric synchronization between both hemispheres shown by our observations is needed to be verified in future. The spatiotemporal variations of streaks and mottled and patchy patterns obtained after the high-pass filtering should be one of key clues for understanding the atmospheric dynamics (e.g., super-rotation) at the cloud top altitudes. It is essential to shed light on the relationship of the various features seen in mid-infrared and UV.

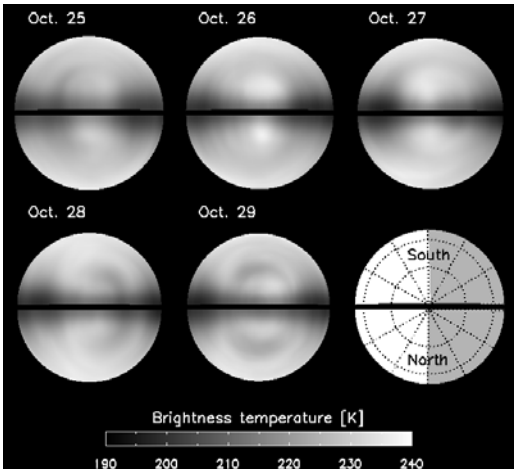

Figure 1. Polar stereographic images at 8.66 μm. The upper and lower parts of each image are south and north polar views, respectively.

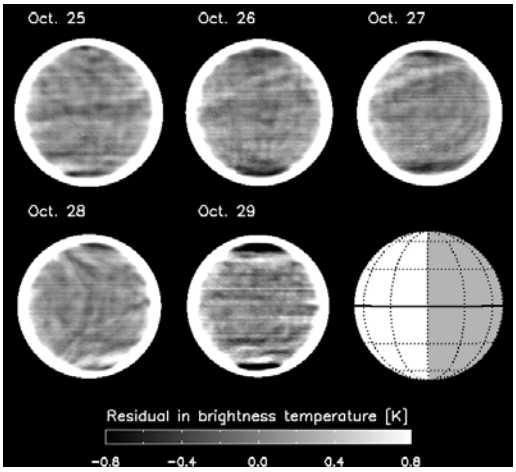

Figure 2. Day-to-day variations of residual patterns at 8.66 μm after the high pass filtering. The lower-right image illustrates the dayside (white) and the nightside (gray) of Venus on 25 October 2007.

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