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Spatiotemporal variations of Venus middle atmosphere revealed by Subaru/COMICS

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Abstract

We report the spatiotemporal variations of brightness temperatures of Venus at cloud top altitudes (~70 km) obtained by the Cooled Mid-Infrared Camera and Spectrometer (COMICS), mounted on the 8.2-m Subaru Telescope. The two important findings are (1) the brightness temperatures at north polar regions were synchronized with those at south polar regions at least in the three observation nights and (2) there were some streaky patterns as were seen in UV and these patterns varied from day to day.

1. Introduction

The middle atmosphere (60−100 km) of Venus plays an important role in determining its own environment. 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]. More than 70% 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 [2,3]. This horizontally and vertically unusual heating in the cloud layer excites the thermal tides, which are key process to understand the atmospheric super-rotation. In order to elucidate this mysterious atmospheric phenomenon, it is fundamental to investigate horizontal and vertical thermal structure in the middle atmosphere.

2. Observations

Venus observations were conducted at three mid-infrared wavelengths (8.59, 11.24, and 12.81 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) at observation period were ~25" and ~90˚, respectively. The spatial resolution of images was ~500 km/pixel for the sub-observer point. This was the first time that such high spatial resolution full-disk images had been obtained at mid-infrared wavelengths [4].

3. Results

Shown in Figure 1 are the calibrated brightness temperatures at 8.59 μm focused on polar regions of Venus on 26, 28, and 29 October 2007. The brightness temperatures at cloud top altitudes (~70 km) in north polar regions were synchronized with those in south polar regions. Such atmospheric synchronization has not been reported by any previous mid-IR ground-based [5,6] and satellite observations [7] mainly because of low spatial resolution and of the polar orbits of the satellites, respectively. Figure 2 presents the Venus images at 8.59 μm after high-pass filtering. We find that there were some streaky patterns, amplitudes of which were ~0.5 K, and these patterns varied from day to day. It is worth noting that streaky patterns obtained on 28 October 2007 were similar to a well-known horizontal Y-shape structure seen in UV. The above two findings are also seen at the other wavelengths.

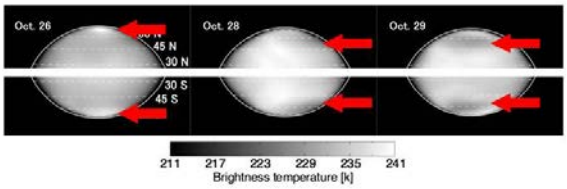

Figure 1: Brightness temperatures at 8.59 μm focused on Venus polar regions on 26, 28, and 29 October 2007. Warmer and colder regions (thick red arrows) appeared at the same time in both north and south polar regions, and rotated in synchronization.

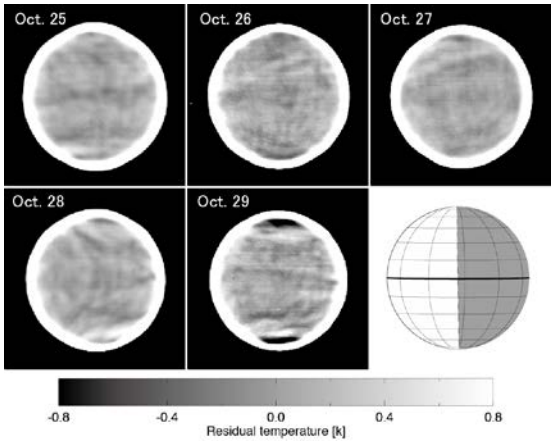

Figure 2: Venus images at 8.59 μm during the period of 25−29 October 2007 after high-pass filtering. The lower right illustration shows the dayside (white region) and nightside (gray region) at observation period.

4. Summary

The mid-infrared observations with Subaru/COMICS provided a valuable insight about the brightness temperature distributions of Venus at cloud top altitudes. The spatiotemporal variations of streaky structures obtained after high-pass filtering should be one of key clues for understanding the atmospheric dynamics (e.g., super-rotation) at these altitudes. In this talk, as a first step, we will present what kind of atmospheric parameters are responsible for the amplitudes of these streaky patterns through radiative transfer calculations.

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References

[1] Crisp, D. and Titov, D.: The thermal balance of the Venus atmosphere, in Venus II, Univ. of Ariz. Press, 1997.

[2] Tomasko, M.G., Doose, L.R., Smith, P.H., and Odell, A.P.: Measurements of the flux of sunlight in the atmosphere of Venus, J. Geophys. Res., Vol. 85, pp. 8167−8186, 1980.

[3] Tomasko, M.G., Doose, L.R., and Smith, P.H.: The structure of the clouds of Venus and the atmospheric heating rate due to the absorption of solar energy, Adv. Space Res., Vol. 5, pp. 71−79, 1985.

[4] Mitsuyama, K., Nakamura, M., Imamura, T., Satoh, T., and Kasaba, Y.: Temporal variations of Venus cloud-top thermal structures: Mid-infrared ground-based observations, 37th COSPAR Scientific Assembly, 13−20 July 2008, Montréal, Canada, 2008.

[5] Apt, J. and Goody, R.: Anomalous features in thermal radiance maps of Venus, J. Geophys. Res., Vol. 84, pp. 2529−2538, 1979.

[6] Orton, G.S., Caldwell, J., Friedson, A.J., and Martin, T.Z.: Middle infrared thermal maps of Venus at the time of the Galileo encounter, Science, Vol. 253, pp. 1536−1538, 1991.

[7] Taylor, F.W., Beer, R., Chahine, M.T., Diner, D.J., Elson, L.S., Haskins, R.D., McCleese, D.J., Martonchik, J.V., Reichley, P.E., Bradley, S.P., Delderfield, J., Schofield, J.T., Farmer, C.B., Froidevaux, L., Leung, J., Coffey, M.T., and Gille, J.C.: Structure and meteorology of the middle atmosphere of Venus: Infrared remote sensing from the Pioneer Orbiter, J. Geophys. Res., Vol. 85, pp. 7963−8006, 1980.