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Spatiotemporal variations of brightness temperatures in the middle atmosphere of Venus revealed by Subaru/COMICS

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The middle atmosphere (60-100 km altitudes) 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 (Crisp and Titov, 1997). 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 (Tomasko et al., 1980, 1985). This horizontally and vertically unusual heating in the cloud layer excites the thermal tides, which are the 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.

We conducted Venus observations at three mid-infrared wavelengths (8.66, 11.34, and 12.84 micron) with the Cooled Mid-Infrared Camera and Spectrometer (COMICS), mounted on the 8.2-m Subaru Telescope, during the period of October 25-29, 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 the observation period were ~25 arcsec and ~90 deg (i.e., both the dayside and nightside hemispheres were observed), respectively. The spatial resolution of the observed images, which was determined by astronomical seeing, was ~200 km for the sub-observer point. This was the first time that such high spatially-resolved images had been obtained at mid-infrared wavelengths (Mitsuyama et al., 2008).

From images at 8.66 micron, we obtained three important findings. First, the brightness temperatures at cloud top altitudes (~70 km) in north high-latitudes seemed to be synchronized with those in south ones during the period, which implies that the rotational speeds of them were nearly identical in both high-latitudes. Such atmospheric synchronization has not been reported by any previous mid-infrared ground-based (Diner et al., 1982; Orton et al., 1991) and spacecraft (Taylor et al., 1980; Zasova et al., 2007) observations mainly because of low spatial resolution and tilt of Venus' north pole toward the Earth, and of restricted distribution of sounding, respectively. Second, the center-to-limb curves (dayside and nightside) showed a day-night asymmetry across the morning terminator except that those on October 25 were nearly symmetric. The magnitude of this asymmetry was variable from one day to the next. Such day-night asymmetric features would result from the differences of temperature and/or cloud optical thickness. Finally, there were some streaky and patchy patterns in the whole disk after high-pass filtering. These patterns, typical amplitude of which was ~0.5 K, varied from day to day. It is worth noting that streaky patterns obtained on October 28 were similar to a well-known horizontal Y-shape structure seen in UV. The above three findings were commonly seen at the other wavelengths.

In this talk, we show the observational results and discuss what kind of atmospheric parameters are responsible for the anomalous features of planetary scale center-to-limb curves through radiative transfer calculations.

Keywords: Venus, middle atmosphere, ground-based observation, atmospheric synchronization, center-to-limb curve, small-scale streaky and patchy patterns