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Venusian cloud top temperature obtained by LIR onboard Akatsuki

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Abstract

The longwave Infrared Camera (LIR) onboard Akatsuki has taken the image nightside hemisphere of Venus on 9 December.The image which converted to the brightness temperature showed the remarkable contrast with polar collar. Moreover, patchy temperature structures with horizontal scales of several hundred to a thousand kilometers have been seen. It would reflect horizontal variations in cloud-top altitude.

1. Introduction

Infrared observations of the Venusian atmosphere were conducted by several Venus orbiters in the past. Pioneer Venus Orbiter Infrared Radiometer (OIR) observed the north polar region of Venus and discovered the characteristic temperature structure called “the polar dipole” and “the polar collar” [Taylor et al., 1980]. Infrared Fourier Spectrometer (IFS) onboard Venera-15 measured a spectral region of 6-40 μm with a spectral resolution of (5 cm^{-1}), retrieving a meridional cross section of temperature distribution [Moroz et al., 1986; Oertel et al., 1987]. Thermal Imaging Spectrometer (VIRTIS) onboard Venus Express revealed that temperature distribution in the south polar region is similar to that in the north pole [Piccioni et al., 2007]. However, the Venusian atmosphere especially in the middle and low latitude regions has not been thoroughly surveyed by thermal infrared yet.

The longwave Infrared Camera (LIR) onboard the Venus orbiter Akatsuki is designed to acquire a thermal infrared image of Venus. Although the spatial resolution is lower than other cameras onboard Akatsuki, it takes an image of both dayside and nightside with an equal quality. Temperature and wind vector fields at an altitude of Venus’s upper cloud-top would have been obtained from the thermal images taken by LIR in an equatorial orbit [Taguchi et al., 2007; Fukuhara et al., 2011]. Unfortunately, the spacecraft has failed to insert the Venusian orbit on 7 December 2010, and is currently orbiting around the Sun in an elliptic orbit that has a little smaller semi-major axis than that of Venus’s orbit. However, two days later, LIR successfully acquired 10μm infrared images of entire nightside hemisphere of Venus for the first time from space.

2. Data acquisition procedure

We obtained a single accumulation image (M=1 and N=1, where M and N are number of the first and second accumulation onboard the spacecraft) and an accumulated image (M=32 and N=32) on December 9 at a distance of about 600,000 km, and another single accumulation image on December 10 at a distance of about 890,000 km. It takes 128 second to acquire the accumulated image.

When LIR acquired images, the inclination of the spacecraft was unusually larger than nominal case. As the result, the attitude control system could not keep the stability of spacecraft completely during the observation. As the sight slowly drifted for 3 pixels in X and Y directions for 128 second, the edge of the Venus disk faded. Therefore the 32 raw images before accumulation were downloaded to ground station and reprocessed after correction of the attitude variation. The Venus disk which the outline has improved was converted to the brightness temperature by using the reference data acquired in the laboratory experiment before the launch.

3. Temperature distribution

The reprocessed image shows the low temperature distribution in the both polar regions. Although limb darkening due to an increase in optical path length as approaching the limb and a decrease in temperature as height in the cloud-top altitudes is apparent, the low temperature region which would correspond to

the polar collar is remarkable in the northern high latitudes. Other zonal structures can be seen in the middle and low latitudes, and they may correspond to ultraviolet structures seen in the previous Venus observations. Moreover, patchy temperature structures with horizontal scales of several hundred to a thousand kilometers are seen, and it may reflect horizontal variations in cloud-top altitude.

4. Further work

It is significant that the LIR image is compared with Venus express data that has been acquired at the same period. For instance, the cloud top altitude will be obtained when the horizontal cloud top distribution by LIR is applied to the Vertical temperature profile estimated from VIRTIS and radio science experiment. Comparison with the ultraviolet contrast structure will progress the discussion of cloud top morphology. It is also significant that integrated thermal radiation of the whole disk can be estimated by LIR observation for studying planetary energy budget.

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