Study of the polar oval at the cloud top of Venus using spectral images taken by Venus Express

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Venus is covered by highly-reflective thick clouds composed mostly of sulfuric acid. Because of the near-uniform distribution of the upper cloud and the absence of notable absorption, the Venus disk is almost featureless in the visible wavelength range.This contrasts with the ultraviolet range, where distinct albedo features are observed at the cloud top (e.g., Rossow et al., 1980). The Venus’ albedo in the visible range is as high as 0.8, but the weak solar absorption in this wavelength range is still important for Venus' heat balance because the solar energy is large in the visible range.
Polar oval is one of the few absorption features observable in the visible wavelength region. Little is known about the whole shape of the polar oval, its variability and optical characteristics. In this paper, we reconstruct the whole shape of the oval from Venus images taken continuously by the VMC onboard ESA’ s Venus Express, and clarify the optical properties of polar oval by analyzing the image taken by VIRTIS onboard Venus Express. We first estimated the period of the rotation of the oval around the pole from the longitudinal movement of polar oval seen in VMC visible images. The estimated zonal rotation period is ~3.5 days. This value is comparable to the wind velocity in the polar region estimated by cloud tracking using ultraviolet images taken by Pioneer Venus OCPP (Limaye, 2007), and thus the oval seems to be drifted mostly by the superrotation. Next, we created mosaic images by connecting images obtained in four successive orbits after shifting in longitude considering the zonal rotation speed of 360°/3.5 days. The mosaicing allowed us to reconstruct the shape of the polar oval. The shape of the oval was found to be changing over time between elongated shape and near-circular shape. The dominant period of this variation changes with time in the range of 200-350 Earth days, and does not seem to coincide with the orbital period, the rotation period, and the length of the day. This suggests that the variation of the oval shape is driven by some internal nonlinear process. We further analyzed VIRTIS spectral images, and found that the albedo at the dark edge of the polar oval is declined by 2-25% in the broad wavelength range from ultraviolet to near-infrared. This suggests that the absorber accumulated in the polar oval has a wide absorption band unlike the unknown UV absorber, which creates albedo contrast in all latitude regions. We also found that the brightness temperature is increased by ~5 K along the dark edge of the oval and that no rise or depression of the cloud top occurs there. Calculation of the heat balance at the dark edge of the polar oval shows that the albedo variation will be responsible for the temperature variation across the polar oval.

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