Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

U003-23 会場:304 時間:5 月 27 日 15:45-16:00

Cloud morphology and atmospheric dynamics from the Venus Express observations

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Since its orbit insertion in April 2006 the ESA Venus Express spacecraft has been performing a global survey of the Venus atmosphere. The powerful suite of remote sensing instruments that includes cameras, spectrometers and radio occultation experiment provided the largest and the longest set of atmospheric data collected so far. Coordinated use of various observation techniques enables investigation of different aspects of the Venus atmospheric physics. This paper focuses on the study of the cloud morphology and dynamics of the Venus atmosphere by synergistic use of the data from the Venus Monitoring Camera (VMC), Visible and Infrared Thermal Imaging Spectrometer (VIRTIS), and radio science (VeRa) experiments.

The VMC camera investigates the cloud top morphology by imaging at 365 nm - characteristic wavelength of the unknown UV absorber. Low latitudes (< 40 deg) are dominated by relatively dark clouds that have mottled and fragmented appearance clearly indicating the presence of turbulence in the sub-solar region. At ˜50 degrees latitude this pattern gives a way to streaky clouds suggesting that horizontal flow prevails here. Poleward from ˜60 degrees the planet is covered by almost featureless bright hood crossed by dark thin (˜300 km) spiral or circular structures. The features of the global UV pattern are qualitatively explained by changes in the temperature structure and atmospheric stability with latitude. Simultaneous imaging in the UV and thermal-IR ranges showed that the cloud patterns on the day and night sides are correlated.

Joint analysis of the VIRTIS spectro-imaging data and the VeRa temperature sounding revealed remarkable changes in the vertical structure of the Venus cloud tops. The cloud top altitude changes from 74+/-1 km in the low and middle latitudes to about 64 km in the polar region marking vast polar depression. The descent of the cloud top correlates with drastic changes in aerosol scale height from 3.8+/-1.6 km to 1.7+/-2.4 km. The altitude of the sharp cloud top inside and poleward from the cold collar region coincide with position of strong temperature inversion, thus indicating its radiative origin.

Tracking of cloud features in the VMC UV images allowed characterization of the mean state of the atmospheric circulation at the cloud tops as well as its variability. An almost constant zonal wind speed of 90+/-10 m/s at low and middle latitudes gives way to the wind that quickly vanishes with latitude. The meridional poleward wind ranges from 0 m/s to about 20 m/s. Thermal wind field derived from the VIRTIS and VeRa temperature sounding using cyclostrophic approximation is in good agreement with the cloud tracked wind pattern indicating validity of the cyclostrophic balance.

キーワード: Venus Express, Clouds, Atmospheric dynamics
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