Stationary features at the cloud top of Venus observed in Akatsuki UV images

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Using the cloud image obtained with the Ultraviolet imager (UVI) on board the Venus orbiter "Akatsuki", we detect stationary fine features fixed to the terrain and investigate their origin. Huge bow-shaped structures extending from northern to southern high latitudes have been discovered by the Longwave infrared camera (LIR), which is also installed in Akatsuki, and such structures have been observed several times. Since they appear above certain highlands and continue to be there against the zonal wind, they are attributed to topographic gravity waves. This study shows that there exist similar features also in other wavelengths.

Variations of the vertical wind have been observed over the Aphrodite Terra (altitude 3000~4000 m) by the VEGA balloon in 1985, and recently the cloud tracking using cloud images taken by VMC on board Venus Express showed that the zonal wind speed is decreased above the Aphrodite Terra. These two studies suggested the existence of gravity waves and their important role in momentum transfer. Gravity waves, whose restoring force is buoyancy, are considered to be generated preferentially in the lower atmosphere and propagate upward. When they break at cloud height, the momentum and energy transported from the lower layer are delivered to the background atmosphere, and then the mean zonal wind is decelerated. Since this effect is an important factor for understanding the super-rotation, understanding of gravity waves is crucial. From such a viewpoint, we identify topographically fixed structures in Akatsuki UVI images, study geographical and local time dependences, and constrain the properties of gravity waves such as the horizontal wavelength and the amplitude. We also compare images taken at 283 nm, where the absorption by SO2 dominates, and 365 nm, where absorption occurs due to unknown absorbers, to study the difference in the response of the cloud layer between the wavelengths.

We use L3 data projected onto the latitude and longitude coordinate. In order to extract structures fixed to the terrain, we average multiple images taken in a particular orbit to smooth out moving features and apply high-pass filtering by subtracting a Gaussian-smoothed image, thereby emphasizing stationary features.

First we analyzed the 283 nm image taken on 7th December 2015, which is the date of Venus orbit insertion. At this wavelength, absorption of sunlight by sulfur dioxide is dominant. In this data we identified stationary structures like scratches running in the north-south direction near the equator. Analyzing all available L3 data of 283 nm, we found that all of the stationary structures appeared exclusively above highlands near the equator, and that they tend to appear around the local time from noon to the evening. The horizontal wavelengths are about 200-300 km. Bow-shaped structures were observed by LIR also in these geographical regions and local time, suggesting a common dynamical mechanism behind the stationary features observed by UVI and LIR. We also analysed 365 nm images and found that stationary features are not clearly seen at this wavelength except for the cases where the amplitude of the feature at 283 nm is large or the background fluctuation of the 365 nm contrast is small. Although the material absorbing sunlight at this wavelength is unknown, the difference in the appearance from 283 nm can constrain the altitude distribution and chemical life time of this material.

Based on the topographically-fixed nature and the small-scale wavelike structure, we assume that the observed features are generated by gravity waves excited near the surface. We model the responses of the distributions of sulfur dioxide and cloud particles to a gravity wave and derive wave parameters by comparing the model result and the observed brightness variation. We also plan to estimate the amount of momentum that gravity waves deliver to the cloud layer and study the influence on super-rotation.

Keywords: Venus, Akatsuki, UVI, Gravity wave

