

New thermal infrared camera for fine horizontal brightness temperature structures at the cloud-top level of Venus

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The Longwave Infrared Camera (LIR), which is an uncooled microbolometer camera, is currently acquiring thermal infrared images (8-12 μm) of Venus and depicting the cloud-top brightness temperatures from Akatsuki orbiter around Venus since December 2015. The outstanding result of LIR has been the discovery of an interhemispheric bow-shaped structure meridionally stretching 10,000 km across the equator at the Venus cloud-top. Over several days of observations, the bow-shaped structure remains relatively fixed in position above the highland on the slowly rotating surface, despite the background atmospheric super rotation at ~ 100 m/s. We infer that the bow-shaped structure is the result of an atmospheric gravity wave generated in the lower atmosphere by mountain topography that then propagated upwards [1]. This indicates that the horizontal temperature distribution seen at the cloud-top level represents not only direct physical property at the cloud-top but also influence of dynamics in the lower atmosphere. In fact, preliminary observation of LIR has detected fine structure (~ 100 km) in temperature distribution from close-up observations near the periapsis. We suggest that this may be caused by the upward propagation of a gravity wave, which is generated by the convection layer at ~ 40 km altitude. However, the spatial resolution of LIR seems insufficient to understand the origins of such a fine structure. We need better observations at higher spatial resolution than possible from LIR in Akatsuki's orbit.

We propose that a future Venus orbiter carries an updated version of the uncooled microbolometer camera (BOL) with 1024x768 pixels and angular resolution of ~ 0.01 deg/pixel to detect fine temperature structure on the cloud-tops. When the orbiter is typically injected to a high-inclined elliptical orbit with altitude of 500-50,000 km, BOL provides a spatial resolution of 8.5 km at apoapsis and 0.08 km at periapsis, respectively. It will be enough to observe the fine temperature structure at the cloud-top. Further, BOL will capture the fine temperature structure at polar region near the "eye" of the hemispheric vortex situated over the poles, where the horizontal temperature varies drastically near the Venus cloud-tops. VIRTIS instrument on Venus Express orbiter showed complex structures at near infrared wavelengths [2]. Akatsuki from its near equatorial elliptical orbit cannot observe the fine structure in polar regions.

During 2012-2014, we developed an uncooled micro-bolometer array (UMBA) camera for the 50 kg class Earth observing satellite based on the experience of LIR development [3]. The camera with the pixel size of 640 x 480 was launched in 2014 and successfully detect a small wildfire which was main observation target for the mission. The results showed that its performance was better than expected. Furthermore, the newest UMBA camera with the pixel size increased to 1024 x 768 has been developed for the next wildfire mission to take finer spatial resolution image with ~ 0.01 deg/pixel. Unfortunately, this camera has lost the launch opportunity. However, the flight-model has been assembled and has passed function tests. Since BOL does not need heavy cryogenic systems, its mass and size are less than ~ 1 kg and 100 mm x 100 mm x 120 mm, respectively; it would be a relatively small mass increment for the future Venus mission.

References

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