

Current status of observation by the Longwave Infrared Camera (LIR) on board Akatsuki spacecraft

T. Fukuhara¹, M. Taguchi¹, T. Imamura², T. Kouyama³, M. Nakamura⁴, T. M. Sato⁴, M. Suzuki⁴, N. Iwagami⁵, M. Ueno⁶, G. L. Hashimoto⁷, M. Sato⁸, M. Futaguchi⁹, S. Takagi¹⁰, ¹Rikkyo University, ²The University of Tokyo, ³AIST, ⁴ISAS/JAXA, ⁵Senshu University, ⁶Kobe University, ⁷Okayama University, ⁸Hokkaido University, ⁹Toho University, ¹⁰Tokai University.

Introduction: Akatsuki has started observation of the Venus atmosphere since 2015 [1]. Immediately after the orbit insertion of the spacecraft, LIR discovered a large stationary gravity wave which appeared above the highland of Aphrodite Terra toward evening [2]. We advance the study by using the abundant LIR images, and various large stationary gravity waves have been identified in LIR images. On the other hand, brightness temperature derived from LIR images contained an unexpected bias that related not to natural phenomena but to a thermal condition of the instrument. Causes of the bias have been investigated and corrected by using calibration data derived from deep space images.

Large stationary waves: 8 stationary waves also have been identified in the LIR observations since the first discovery of the wave above Aphrodite Terra. The apparent wave fronts are roughly aligned in the north-south direction and the meridional span exceeds 2000 km in all cases. The peak-to-peak amplitudes of the brightness associated with the waves are larger than 1 K. All of the center positions of the stationary waves correspond to four specific highlands in the low latitudes but not in the high latitude. They periodically appeared when these regions were toward evening, while the wave amplitudes attenuated after the wave locations passed beyond the evening terminator.

We consider three outstanding issues of the stationary gravity waves. (1) Why is the local time of the waves appearing limited toward evening? Does a source of the wave near the surface appear only in the specified local time? Does the specified altitude such as cloud layer where the static stability is relatively low and generates convection disturb wave propagation to upward? (2) How is the wave source near the surface generated at the highland areas? Does a weak wind or a temperature anomaly near the surface generate atmospheric disturbance? (3) Why is the stationary gravity waves not observed at the high latitude? The Maxwell Mountain located at latitude of 65.2°N is the highest mountain on Venus. However, no wave has been detected there. Does the equatorial orbit of Akatsuki not meet observations of the high latitude area? Does the feature become obscure in the prominent feature such as a polar dipole? Does the wave not be generated at the highland in the high latitude area?

Numerical studies would be a potential tool to clarify the issues.

Correction of a systematic bias: LIR provides horizontal distributions of the brightness temperature on the Venus disk in both dayside and nightside by detecting emissions at wavelengths from 8 to 12 μm [3]. Simulation of radiative transfer with a typical cloud height distribution in the Venus atmosphere indicates that the thermal infrared radiation emitted from an altitude of ~ 65 km mostly contributes to the thermal contrast in the LIR images [4]. The brightness temperature at that altitude is generally ~ 230 K according to the vertical temperature distribution of the Venus atmosphere derived from previous observations [e.g., [5]]. However, it became clear that images include background-offset more than 20 K unrelated to cloud features. LIR has two suspicious noise factors on orbit; one is power-supply management and the other is variation of solar incident angle accompanying temperature deviation of instrument. The power supply unit turned on the instrument before every observation, which obviously affected thermal balance. Hence, we have improved operation procedure of LIR observation; power status of the instrument has been changed to normally turn-on. Consequently, thermal potential of the instrument have been stable with background offset decreasing. The offset still remaining has well correlated with temperature of baffle which prevents sunlight input to the detector. The baffle is configured outside of spacecraft and temperature drastically changes with solar incident angle. It probably affects thermal potential of the germanium lens which would be major cause of the offset. Deep space observation with solar incident angle gradually changed has been carried out. Reference table for correction of background offset has been derived from the observation, and it has been confirmed that the offset can be well corrected by the reference table.

References:

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