Long-term steadiness of thermal tide structures in zonal and meridional wind fields at the cloud top of Venus

*Toru Kouyama[1], Masahiro Takagi[2], Takeshi Horinouchi[3], Kazunori Ogohara[4], Hiroki Kashimura[5], Norihiko Sugimoto[6], Shin-ya Murakami[7], Takeshi Imamura[8], Takehiko Satoh[7], Masato Nakamura[7]

1. National Institute of Advanced Industrial Science and Technology, 2. Kyoto Sangyo University, 3. Hokkaido University, 4. University of Siga Prefecture, 5. Kobe University, 6. Keio University, 7. Japan Aerospace Exploration Agency, 8. University of Tokyo

Atmospheric acceleration due to thermal tides enhanced in the cloud layer has been considered as one of main contributors for maintaining the atmospheric super-rotation in Venus [e.g. Fels and Lindzen, 1974], where zonal wind speed of the atmosphere at the cloud top (~70 km) rotates more than 60 times faster than the rotation speed of the solid body of Venus. The structures of the thermal tides have been confirmed firstly in a temperature field [Taylor et al., 1980] and in zonal and meridional wind fields at the cloud top level by tracking cloud motions in several Venus exploration missions [e.g. Limaye and Suomi, 1981; Limaye 1988; Rossow et al., 1990; Moissl et al., 2009; Kouyama et al., 2012]. Based on the observational results, it has been considered that the existence of thermal tides is quite stable. On the other hand, there have been less studies about quantitative investigation of steadiness or temporal variations of wind speed structures due to thermal tides, such as amplitude of wind speed variation and phase relationship between zonal and meridional winds, which may provide hints for numerical simulation for evaluating more realistic contribution of thermal tides for maintaining the super rotation. In addition, it should be worth to investigate whether local topography affects the thermal tides structures.
In this study, we investigated stability or temporal variation of wind speed structures due to the thermal tides based on observed images taken with Venus Monitoring Camera (VMC) on board Venus Express. The data period is about 7 years (from 2006 to 2013), though there were data gaps of 100 days in every Venus year (224 days) because of VMC observation condition. We confirmed characteristics of the structures due to thermal tides same as previous studies, that is, zonal winds in day-side region, for example, took a local minimum at around local noon in equator region and it was 10 m/s faster than the local minimum around local morning and evening regions. The local time of the local minimum was almost same among different observation periods, and wind speed difference between local noon and local evening/morning was also similar, although there was a clear temporal variation in dayside mean zonal wind speeds as reported in Kouyama et al. (2013) and Khatuntsev et al (2013), whose peak to peak variation was more than 20 m/s. In addition, we also investigated longitude dependence (or local topography dependence) of zonal wind speed, which was suggested in Bertaux et al (2016), in each period of dayside observation sequence of VMC (~80 days). When we averaged zonal wind speed in whole data periods, we confirmed the apparent correlation between zonal wind distribution averaged and surface topography of Venus same as Bertaux et al (2016). On the other hand, it was hard to confirm the correlation when we averaged zonal wind speed in each observation period. In addition, in any longitude zonal wind speed showed a similar temporal variation during VMC observation period, so that we consider it is hard to distinguish local topography dependence of zonal wind speed from the temporal variation of the background mean zonal wind speed and wind speed variation due to observable local time transition.

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