Study on the thermal structure of the Venusian polar atmosphere

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The Venus atmosphere exhibits characteristic thermal features called ’polar dipoles’ and ’polar collars’in both polar regions. The polar dipole which locates around the center of the polar region is warmer than mid-latitudes and the polar collar surrounding the polar dipole is colder than the other regions at the same altitude. These features were revealed by infrared observations of Venus by the previous missions Pioneer Venus and Venus Express. The polar dipoles and polar collars are attributed to the residual mean meridional circulation (RMMC) enhanced by the thermal tide. In the high latitudes downward advection driven by RMMC adiabatically heats the polar atmosphere inducing the warm polar dipole, and conversely, in the latitudes equatorward of the polar dipole, upward advection driven by RMMC adiabatically cools the atmosphere inducing the cold polar collar. These results are reproduced by a numerical simulation of the Venus atmospheric circulation [Ando et al., 2016].

The previous observations showed that shapes of the polar dipoles can be characterized by three patterns which are the zonal wave numbers of 0-2, and that they change with time [Garate-Lopez et al., 2013]. The rotation periods of polar dipoles were determined to be 2.5 Earth days [Piccioni et al., 2007] and 2.8-3.2 Earth days [Schofield et al., 1983] for the southern and northern polar regions, respectively. It has not been clear that the difference and variability in the rotation period is due to just a temporal variation, influence of solar activity, or other reasons. Sato et al. [2014] compared the appearances of both polar hot regions by a ground-based observation, rotation of the hot regions is synchronized between the northern and southern hemispheres. However, rotation periods of the northern and southern polar dipoles have not yet been directly compared.

The Japanese Venus orbiter Akatsuki is a planetary meteorological satellite aiming at understanding the atmosphere dynamics of Venus. The Longwave Infrared Camera (LIR), observes thermal emission from the cloud top (˜65km) [Fukuhara et al., 2011]. Since Venus Express was in a polar orbit with an apoapsis located above the south pole, it extensively investigated the southern hemisphere. On the other hand, Akatsuki is in an equatorial orbit, which is suitable for simultaneous observations of both northern and southern polar regions. Variations of thermal features in the polar regions can be retrieved from more than two successive images obtained by LIR with a time interval of several hours.

Rotation periods of polar vortices were derived using the LIR data by tracking a zonal position of maximum temperature. The rotation periods of polar vortices of southern and northern hemispheres are determined to be 3.0 - 8.2 and 1.6 - 5.5 Earth days, respectively (Fig.1). These rotation periods of southern polar vortex are significantly longer than the values observed in the past.

As a next step, we will derive rotation periods of the polar vortices for other observation periods. From these results, possibility of north-south symmetrical rotation of polar vortices, temporal variation of the rotation period and its dependences on local time and spatial resolution will be discussed. Relation between the variation in rotation period and global circulation will help to understand the dynamics of Venusian atmosphere.

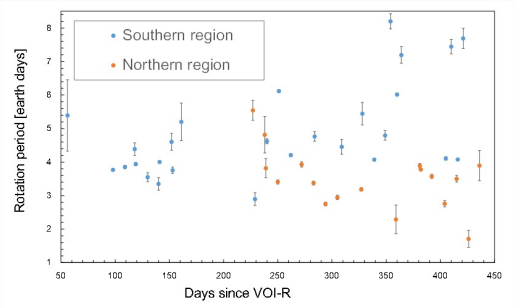

Fig.1. The rotation periods of polar vortices derived from LIR data from 50 to 450 days after Venus orbit insertion (VOI-R) of Akatsuki on Dec. 7, 2015 (Jan. 2016 ~ Feb. 2017).