Characteristic of polar dipoles seen by LIR onboard the Venus orbiter Akatsuki

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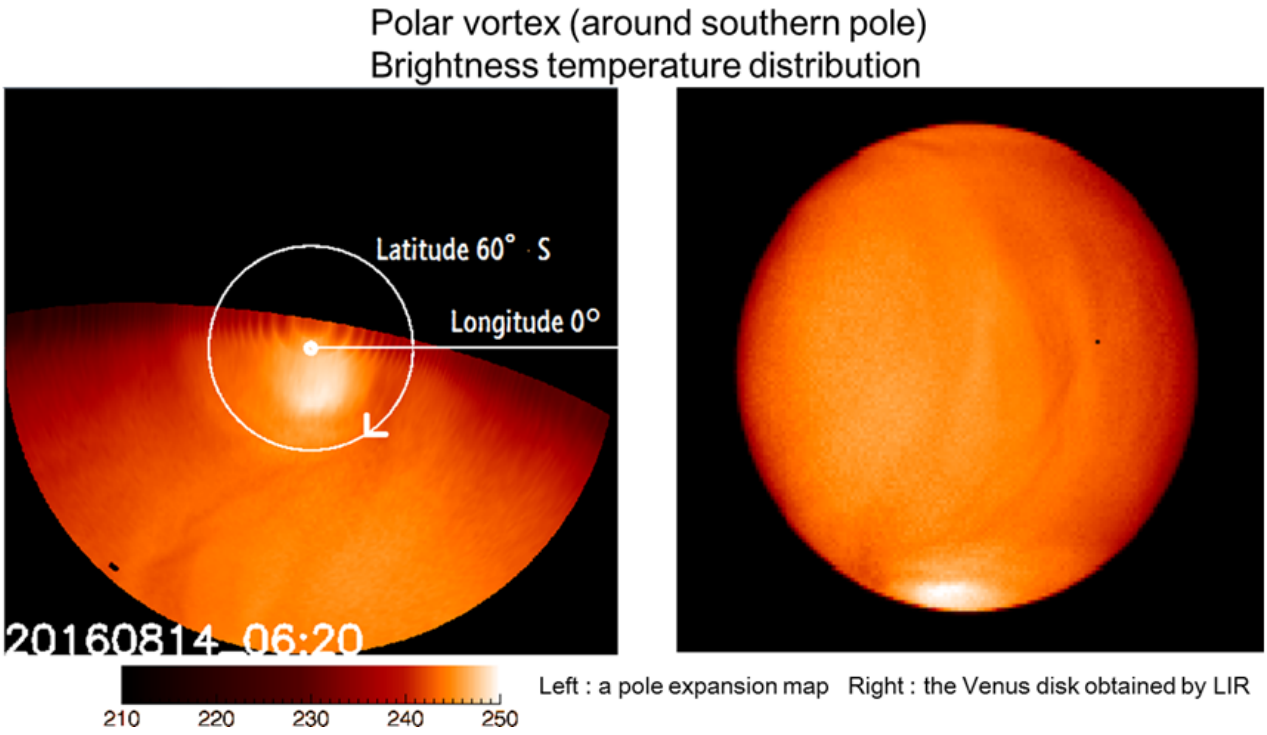
The Venus atmosphere exhibits characteristic thermal features called ‘polar dipoles’ and ‘polar collars’ in both polar regions. The polar dipole which locates around the center of the polar region is warmer than mid-latitudes and the polar collar surrounding the polar dipole is colder than those of the 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 collar 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., 2015].
The previous observations showed that shapes of the polar dipoles can be characterized by three patterns which are a dipole shape, an elongated oval, or a nearly circular structure, 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 or influence of solar activity.
The Japanese Venus orbiter Akatsuki is a planetary meteorological satellite aiming at understanding the atmosphere dynamics of Venus, and now orbiting Venus to make observations by five cameras. These cameras are designed to realize the three-dimensional observation of the atmosphere.
The Longwave Infrared Camera (LIR), which is one of the five cameras, observes thermal emission from the cloud top (~65 km) [Fukuhara et al., 2011]. LIR observes both dayside and nightside with an equal quality. Therefore, LIR can get brightness temperature of a hemisphere facing to the spacecraft. 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. Thermal feature motions in 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 the cross correlation method. Figure shows an example of a brightness temperature distribution of the Venus disk obtained by LIR (right panel) and that projected onto a pole expansion map (left panel). The high temperature region in the southern polar region is clearly identified, and at that time the axis of the polar dipole approximately pointed to the spacecraft. The rotation periods of polar vortices derived from the temperature distributions in the latitude region from 71˚ to 80˚ are 4±2 Earth days and 3±1 Earth days in the southern and northern polar regions, respectively. The rotation periods in the southern polar region are longer than the previous

observation result, and those in the northern polar region are similar to the past observation. In addition, we have confirmed that the period of polar vortex shows temporal variation and latitude dependence. As next steps, we will correct the effect of limb darkening and the absolute temperature in LIR images, and then analyze the rotational periods of the polar vortices more precisely. From these results, possibility of north-south symmetrical rotation of polar vortices, temporal variation and latitude dependence of the rotation period of polar vortices will be discussed, and relation between the variation in rotation period and global circulation will help to understand the dynamics of Venusian atmosphere.

Keywords: Venus Atmosphere, Akatsuki, Polar vortex



Left : a pole expansion map Right : the Venus disk obtained by LIR

