Venus mesospheric dynamics inferred from the Doppler-shift measurements of submm CO lines

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Venus atmosphere is often divided into three regions, particularly from the view point of different mechanisms in the atmospheric dynamics: namely, super-rotating (retrograding zonal flow, RZ) lower atmosphere (from surface to 60 - 70 km in altitude), middle atmosphere (~70 - 110 km), and upper atmosphere where the atmosphere is considered to circulate between day and night hemispheres (Sub-Solar-to-Anti-Solar flow, SSAS) due to the strong thermal gradient (above ~110 km). The middle atmosphere is known as a transition region between the lower and upper atmosphere, and is the subject for this study.

The dynamics of the Venusian middle atmosphere has been investigated through several observational techniques (Lellouch et al., 1997). One is the application of thermal wind equation (cyclostrophic approximation) to the thermal structure obtained by infrared spectrometers (e.g., Piccialli et al., 2008). This method always postulates the validity of the cyclostrophic approximation, which becomes less appropriate at the equatorial region, and also on the assumption of the boundary conditions. Another approach is the Doppler-shift measurement of CO absorption line at the millimeter and submillimeter wavelength using a high frequency resolution (resolving power of ~10^7) heterodyne instrument, which gives us the line-of-sight velocity of wind (hereafter denoted as Doppler-wind) at 95-110 km. Both the single-dish telescopes and interferometers have been used for this purpose (e.g., Lellouch, et al. 2008; Clancy, et al. 2012; Moullet, et al. 2013). Most of the early observations of Doppler-wind made an attempt to describe the mesospheric dynamics by a combination of the circulation patterns of SSAS and RZ. Recent interferometric observations enabled us to spatially-resolve Venus disk, and these new results showed that the observed Doppler-wind map cannot be sufficiently explained by a simple combination of SSAS and RZ flows.

In this study, we compare the previously reported Doppler-wind maps, including the one obtained using ALMA, with outputs of a Venus-atmospheric general circulation model developed by Hoshino et al. (2013). This model includes the momentum transport by gravity waves, and has already shown the qualitative representation of one of the previously measured Doppler-wind maps. We will advance the comparison for all the available Doppler-wind measurements under various solar-phase angles, and discuss possible new description of the mesospheric dynamics in Venus.

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