Development of radiative transfer scheme interactive to the cloud time-variation on Venus General Circulation Model

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We have developed a Venus General Circulation Model (VGCM) that takes into account radiative processes, cloud processes (condensation/evaporation, advection and gravitational sedimentation) and chemical processes related to sulfuric acid clouds/vapor based on CCSR/NIES/FRCGC MIROC [Ikeda, 2011], which enables us to interpret observational results from Akatsuki. Our model has suggested that SO2 is lifted upward into the upper cloud layer in the equatorial atmosphere and changes into sulfuric acid clouds followed by a poleward transport along a meridional circulation [Kuroda et al., to be submitted].
In this study, we have improved the radiative processes of the sulfuric acid clouds in the VGCM. Our previous model calculated the optical depth of the sulfuric acid clouds assuming a fixed mixing ratio profile based on VEX measurements in Haus and Arnold [2010]. Now, we calculate it from a mixing ratio obtained in the VGCM. This is the first VGCM that allows us to self-consistently model the radiative effect of the clouds and the cloud distribution. The simulation started from the equilibrium states of wind, pressure, and temperature fields with horizontally uniform cloud distributions taken from the observed vertical profiles in Haus and Arnold [2010]. After 300 terrestrial days, the atmospheric state converged to a steady cycle. We report the zonal wind field, absorption altitude of solar flux, and cloud patterns reproduced from this simulation.
The maximum zonal wind obtained is 110 m/s at middle latitudes and 70-75 km altitudes, which agrees with the observation from Pioneer Venus [Walterschied et al., 1986], successfully reproducing the superrotation. About 65 % of the incident solar flux is absorbed in the upper cloud layer, and then about 25 % in the lower cloud layer and atmosphere below the cloud layer. Consequently, 160 W/m^2 of the incident solar flux diminishes to 20 W/m^2 on the surface. This feature is in a good agreement with the observational result [Tomasko et al., 1980]. The apparent cloud top altitudes calculated with an optical thickness at 1.85-2.20 μm are ~67 km altitude at the equator, ~65 km at mid-latitudes, and ~61 km at the pole (zonal averaged values). Calculating the optical thickness of SO_2 above the cloud top from the SO_2 mixing ratio, the “Y-feature” observed by UVI is reproduced around 65 km altitude. We will also discuss the zonal wind flux balances, vertical stability profile, and cloud mass flux balance quantitatively.

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