R009-P24
ポスター 2 ：9/25　AM1/AM2 （9:00-12:30）

金星の下層雲の形成におけるケルビン波の役割

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Role of a Kelvin wave in the formation of Venusian lower clouds

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Venus is completely shrouded by sulfuric acid clouds, which are thought to play major roles in the climate system of the planet. The main cloud deck extends from about 48 km up to ~ 70 km, and can be subdivided in three layers according to the extinction coefficient and the particle population. The upper cloud, which is located in the stably-stratified atmosphere around 58-70 km altitudes, is thought to be mostly photochemical origin. The middle cloud located around 50-58 km will be maintained by the condensation of H2SO4 vapor transported from below by convection. The lower cloud, which is located around 47-50 km and is highly variable, is not well understood in terms of the origin and the microphysical properties. Using near-infrared window wavelengths, large opacity variations have been observed, and those variations are thought to occur mostly in the lower part of the cloud layer. A notable feature is a planetary-scale dark cloud propagating with a period of 4.9-5.5 days, which was first discovered by ground-based observations (Crisp et al. 1991). The IR2 camera onboard the Venus orbiter Akatsuki observed this phenomenon more in detail, and found that a planetary-scale cloud discontinuity that spans in the north-south direction characterizes the propagating structure (Satoh et al. 2017; Peralta et al. 2020). The relatively large amplitude near the equator and the zonal propagation faster than the background atmosphere indicate that the cloud opacity variation is basically induced by a Kelvin wave. A Venus GCM reproduced a 5.5-day periodicity in the thickness of the lower cloud driven by a Kelvin wave with a zonal wavenumber of unity (Ando et al. 2021). Nevertheless, the observed sharp discontinuity was not reproduced in the previous models. In this study, the nucleation of cloud droplets in oscillating winds associated with a Kelvin wave is studied using a simplified microphysical model, and the role of the wave in the formation of the lower cloud and the conditions for the appearance of the sharp discontinuity are discussed.