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Latitudinal variations in vertical cloud structure by ground-based multispectral imaging

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Jupiter, the largest planet in our solar system, is quite different from terrestrial planets such as Earth. The atmospheric composition is primarily hydrogen with a small portion of helium. Jupiter emits 1.67 times more radiation than it receives from Sun, which indicates the existence of the substantial internal heat source and presumably vigorous convection. It is important to understand the distribution and optical and physical properties of clouds and haze particles because they play a major role in radiative heat and give information on stratospheric circulation and tropospheric meteorology.

Methane is considered that its altitude distribution is uniform through global scale because it does not condense in Jovian atmosphere. Therefore, it is possible to derive vertical cloud structure by observing reflected sunlight in methane absorption bands and continuum in visible to near-infrared spectral ranges. The traditional imaging observation method using interference filters has been conducted with only a few wavelengths at most (e.g., at only two wavelengths in each methane absorption band: at the band center and adjacent continuum) and hence needs several assumptions to derive atmospheric parameters of vertical cloud structure, resulting in large ambiguities. In previous studies, for example, the base of the upper cloud layer was fixed to be the ammonia condensation level. However, it was found that the upper cloud layer is not composed of only pure ammonia ice from analyses of Galileo/NIMS data [Baines et al., 2002]. Therefore, this assumption is not easily accepted. In this work, we first derive Jovian vertical cloud structure using only ground-based multispectral imaging data without any assumptions for altitudes of aerosols.

We conducted ground-based multispectral imaging observation on two nights from 26 to 27 May, 2008, by our EM-CCD camera system with the liquid crystal tunable filter (LCTF), at total of 47 wavelengths covering two methane absorption bands. The 2-m Nayuta telescope at the Nishi-Harima Astronomical Observatory (NHAO), Hyogo, was used for this observation. We succeeded in acquiring Jovian data cubes with high-spatial resolution (~0.9 arcsec in average) in two methane absorption bands (700-757, 878-950 nm at 3 nm interval) as the sum of the best quality Jovian images obtained in short exposure time (50 ms).

In order to derive the vertical cloud structure and optical properties of aerosols without any assumptions for altitudes of aerosol layers, we newly develop the radiative transfer code with fitting procedure to reproduce observed limb-darkening profiles at multi-wavelength based on Temma et al. [2005].

We examine the cloud structure and optical properties of aerosols at five planetographic latitude regions viz. the STrZ (South Tropical Zone: -25 degrees), the SEB (South Equatorial Belt: -15 degrees), the EZ (Equatorial Zone: 0 degree), the NEB (North Equatorial Belt: 12 degrees), and the NTrZ (North Tropical Zone: 20 degrees), by fitting the theoretical limb-darkening profiles to the observed limb-darkening profiles at total of 17 wavelengths. Major results of the ground-based observation are summarized as follows.

1) The cloud top altitude of the EZ, ~190 mbar, is the highest in those of other four latitude regions (the SEB: ~310 mbar, the STrZ: ~280 mbar, the NEB: ~330 mbar, and the NTrZ: ~280 mbar). It possibly extends to the tropopause, which provides an evidence of strong upwelling in this region.

2) The cloud top altitudes of zones except the EZ are nearly same as that of belts. Meanwhile, the single scattering albedos of cloud layers significantly show latitudinal variations, i.e., the single scattering albedos of zones are higher than those of belts.

We conclude that the visible difference in the reflectivity between the zones except the EZ and the belts should be due to the difference of the single scattering albedo of cloud layer, not due to the altitude difference.