EPSC Abstracts
Vol. 6, EPSC-DPS2011-641-1, 2011
EPSC-DPS Joint Meeting 2011

Scattering Properties of Jovian Tropospheric Clouds for the STrZ inferred from Cassini/ISS data

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Abstract

The accurate information on optical and physical properties of cloud particles is essential for not only estimation of vertical cloud structure but also estimation of radiative heating and cooling. The Cassini/ISS took images at multi-wavelengths and at wide solar phase angles during its Jovian flyby. These data enable us to deduce the scattering phase function of cloud and vertical cloud structure in detail. In order to derive wavelength-dependent scattering phase function, we applied the Mie scattering to both haze and cloud. We found the best fit value (1.65) of the real part of refractive index (n_r) is higher than one for ammonia-ice experimentally derived by Martonchik et al. [1] when we analyzed CB2 data with a reflecting-scattering model. The higher value is needed for reproducing a high backward scattering peak in the scattering phase function

1. Introduction

The knowledge of optical (e.g., single scattering albedo, scattering phase function) and physical (e.g., shape, size) properties of cloud particles are essential to retrieve the vertical cloud structure from remote imaging and spectroscopy. However, the limitation of solar phase angle as viewed from the Earth prevents us from inferring the scattering phase function from ground-based and Earth-orbit observations. The Imaging Photopolarimeter (IPP) onboard the Pioneer 10 provided the first photometric measurements at blue (440 nm) and red (640 nm) at wide solar phase angles (12-150°). The scattering phase function (approximated by two term Henyey-Greenstein function) derived by Tomasko et al. [2] from these data has been used for determination of vertical cloud structure. The Cassini performed the Jovian flyby observations (Nov. 2000 – Mar. 2001) en route to Saturn. The Imaging Science Subsystem (ISS) onboard the Cassini provided new photometric measurements at multi-wavelengths in range from UV to IR and at wide solar phase angles (0-140°). In order to improve our knowledge of optical and physical properties of Jovian cloud particles, we have analyzed the Cassini/ISS data at BL1, CB2, corresponding to 451 nm and 751 nm, respectively.

2. Data

Raw image data were calibrated through CISSCAL ver. 3.6 in order to calculate reflectivity. For BL1 and CB2, we chose the image data at 12 solar phase angles (4°, 13°, 19°, 54°, 71°, 90°, 99°, 108°, 121°, 128°, 136°, and 140°). We extracted the limb-darkening profile at each solar phase angle for the South Tropical Zone (STrZ). Figure 1 shows the reflectivity as a function of μ_0 (cosine of solar incident angle) and solar phase angle for the STrZ at BL1 (top) and CB2 (bottom).

3. Radiative Transfer Model

A reflecting-scattering model (case 1) which consists of gas layer, stratospheric haze, gas layer, and a semi-infinite cloud (e.g., West [3]) was adopted for reproducing the above limb-darkening profiles at CB2. In order to derive scattering phase function with wavelength dependence, we applied Mie theory to scattering by both haze (e.g., Tomasko et al. [4]; West [5]) and cloud. The adding-doubling method was used for calculation of multiple scattering. In case 1, the best fit values of real part of refractive index (n_r) and effective radius (r_{eff}) of cloud are 1.65 and 0.4 μm, respectively. This n_r is higher than one for ammonia-ice experimentally derived by Martonchik et al. [1]. The higher n_r is needed for reproducing a high backward scattering peak in the scattering phase function. In case 1, however, there are some problems that a part of limb-darkening profiles at low solar phase angles do not match modeled ones. In order to overcome this problem, as a next step, we try to consider a modified reflecting-scattering model (case 2) which has an additional thin haze between second gas layer and a semi-infinite cloud. In our presentation, we show detailed model description and these results.

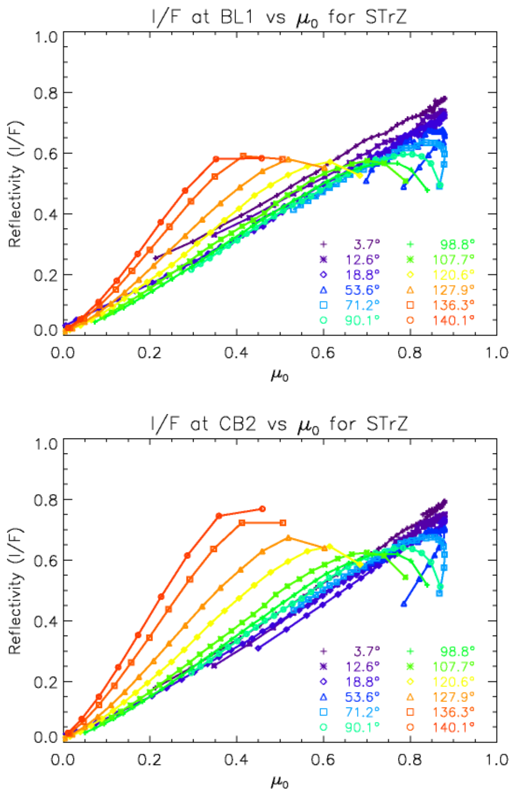

Figure 1: The reflectivity as a function of μ_0 and solar phase angle for the STrZ at BL1 (top) and CB2 (bottom).

Acknowledgements

We are grateful to the Cassini/ISS team for providing valuable data. We also wish to thank Dr. R. West and Dr. B. Knowles for helpful comments for data handling. T. M. Sato is supported by a Grant-in Aid for JSPS Research Fellows.

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