Radiative transfer model combined with multiple scattering in planetary atmosphere: implication for a potential biomarker

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The transit method is one of the main ways to detect extrasolar planets. Analyzing transit transmission spectra of the planets gives us the information on planetary atmospheres, since absorption and scattering by atmospheric molecules have wavelength dependence. As current data points in observed transit spectra are not enough to characterize planets, atmospheric compositions are estimated by comparing with theoretical models. It has been expected to characterize Earth-like planets in future observations. Oxygen and ozone are considered as potential biomarkers which originate from life in an Earth-like atmosphere. Therefore, it will be a good benchmark to find life outside the Earth that we discuss the detectability of these molecules in a variety of conditions.

Our study aims to estimate quantitatively how biomarker molecules are detected in observations. We develop a spherical radiative transfer model based on the TAU code by Hollis et al 2013, and perform mock observations for transmission spectra of Earth-like planets. We deal with multiple scattering in planets by assuming spherical atmosphere. We estimated how Rayleigh scattering and surface reflection affect the detection of biomarkers.

In a clear-sky condition, we evaluate if O2 and O3 are detectable from an Earth-like planet. The shape of the transmission spectrum changes when the planet is covered with the ocean. It indicates that we can identify the reflection from the ocean due to the Rayleigh scattering. In the corresponding wavelength region, absorption of O2 and O3 are too weak to be detected (at 1.27 and 2.47 μm, respectively).

Keywords: extrasolar planet, transmission spectra, mock observation

