Spectral evolution of the Earth's atmosphere

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Significant advances have occurred in the field of extrasolar planet research during the past decade.
The definitive goal of the search for extrasolar planets is the direct detection of radiation from Earth-like planets orbiting nearby stars and characterization of their atmospheres for evidence of habitability and life.
Future space missions such as Darwin and Terrestrial Planet Finder will ultimately offer the opportunity to obtain spectra of extrasolar planets that are situated within the habitable zones of stars and thus search for signs of life.
Accordingly, it is required to develop the database for interpreting those spectra, both for evidence of habitable conditions and for evidence of life.
The mid-infrared spectroscopy is the best suited method to characterize atmospheric conditions and to detect gaseous components such as ozone, carbon dioxide, and methane.
These molecular species are abundant in the Earth's atmosphere and could be attributable to primitive life in extrasolar terrestrial planets.

In order to explore the possibility of diagnosing existence of life from mid-infrared spectra, we have calculated synthesized global infrared spectra for hypothetical terrestrial planets.
So far, the detection of spectral features of the extrasolar terrestrial planets has been discussed mainly for clear atmospheres, not for cloudy atmospheres, although whether any of the terrestrial planets are suitable for life depends on climates as well as volatile abundances.
Because approximately 60% of the Earth is covered with clouds, it is likely that extrasolar terrestrial planets are partially covered with clouds.
It remains unknown whether we could characterize the atmospheric composition of extrasolar terrestrial planets with cloudy atmospheres from observed infrared spectra.
We thus performed calculations of high-resolution mid-infrared spectra of Earth-like planets taking into account global distribution of clouds, viewing angles, seasonal variation in solar insolation and surface temperatures, and consequently, the infrared radiation emitted to space.
In simulating observed spectra of terrestrial planets with cloudy atmospheres, we adopted cloud distributions derived from a general circulation model for the present Earth.

In addition, the ancient Earth has exhibited significantly different atmospheric signatures, which is modified or strongly influenced by life.
The Earth is our only example of a planet whose atmospheric composition is the consequence of the supply of gaseous element from the presence of life.
It is therefore the most suitable place to investigate atmospheric biomarkers.
We thus examine the spectral characteristics with a global atmosphere for the anoxic atmosphere of the early Earth, the ancient Earth just after formation of the ozone layer, and the present Earth.
In this contribution, we will compare the derived spectral features of terrestrial planets and discuss how the cloud radiation has an influence on the detectability of the atmospheric constituents of extrasolar terrestrial planets.